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NOTICE.

Beginning with Vol. XVI., each article has a paging of its own ; and the position of an article in a volume is indicated by the number placed at its head.

It is hoped that this arrangement, which enables us to print papers independently of one another, will ensure a more rapid publication of the material than has been possible heretofore.

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On the Formation of the Germinal Layers in Gastropoda.

By

T. Fujita, *Rigakushi, Nogakushi.*

With 3 plates.

In spite of the fact that within recent years the morphogenesis of the Mollusca has received a great deal of attention from embryologists, there is still much disagreement among authors with regard even to some of the fundamental points in the early phases of development. This is no doubt due to actual differences in developmental processes found in the various animals employed for investigation, and this makes it highly desirable to extend our researches to as many different forms as possible, if we are to arrive at any comprehensive results in these vexed problems. With this aim in view I first paid a great deal of attention to the early development of the Gastropoda, *Siphonaria lepida* GOULD. A preliminary note on that subject was published in the Tokyo Zoological Magazine, Vol. VII., No. 79, 1895. A few years later I undertook a similar investigation on another form, *Aplysia* sp. The conclusions reached in the latter study were

almost the same as those obtained from *Siphonaria*, there being only slight differences in minor details.

The present paper embodies the more essential points brought out in the investigation on these two animals.

THE EGGS.

The eggs of both species here to be considered are deposited on rocks between the tide-marks from the early part of March till late in June. Each form presents so many characteristic differences in egg masses, that it is convenient to describe them under separate headings.

Eggs of Siphonaria:—The eggs of *Siphonaria* are almost always found in masses, the shape of which may be described as an elliptical loop (Fig. 1, Plate I), the last laid portion usually resting on the portion laid first. When oviposition is completed, the head of the animal is pointed in the direction of the arrow in Fig. 1. Pl. I. When magnified the mass is seen to be formed of an innumerable number of oblong vesicles, which are linked one to another by a fine thread, the whole being cemented together by a gelatinous coating. Each vesicle is enveloped in two membranes, very thin and transparent, which are closely applied to each other, and separated only at the poles of the longer axis (Fig. 4). The egg (Figs. 2 and 4 *e*) found in each of these vesicles which must be regarded as the chorion lies rather eccentrically in the portion furthest removed from the genital opening. It is perfectly spherical in form, and is 0.1 *mm.* in diameter. When freshly deposited it is very slightly tinged with yellow, but in course of development it gradually becomes white. In far advanced stages especially in the larval form its color

becomes completely changed to dusky brown, owing to the presence of the shell. Besides the egg there is, within the chorion, an abundant supply of albuminous material uniformly distributed in the form of rather coarse spherules. Fig. 2 shows the general view of the egg in the chorion, which is seen to be enveloped in a thin layer of gelatine not yet coagulated. The spherules just cited are homogenous and translucent; but at about the time of the expulsion of the second polar body, vacuoles are produced in them (Fig. 3). Subsequently, all of the spherules gradually disintegrate, leaving behind only very fine almost imperceptible granules. They, however, can be easily coagulated, and therefore may be brought into view by the application of hardening reagents. By the time this coagulation stage is reached, it is found that the distribution of the albuminous material is no longer uniform throughout as was the case before disintegration. There is almost always a smaller quantity towards the side, which is uppermost in Fig. 4, *i.e.* the future dorso-anterior end of the egg, than on the opposite side.

Eggs of Aplysia:—In this species too, the eggs are deposited in a mass; but here it is in the form of a very long and intricately and loosely entangled cord which is about $1-1\frac{1}{2}$ mm. in diameter. In this cord there is recognizable, even with the naked eye an innumerable number of yellow capsules, which are, as in the case of the former species, connected by a thin thread and enveloped in gelatine. The capsule represents the chorion, and enclosed therein we find eggs usually more than thirty in number (Fig. 37, Pl. II). The egg has a spherical contour, and is about 0.12 mm. in diameter. As is seen in Fig. 38 coarse granules of deutoplasm are conspicuous in that part of the egg which becomes the anterior portion of the future embryo. Their color is very

bright, particularly when fresh, varying from light red to yellow. In advanced stages, however, the color changes completely to dull brown just as in the case of *Siphonaria*.

THE BLASTOMERE STAGE.

Siphonaria:—In three or four hours after deposition, the egg gradually begins to elongate in the antero-posterior direction, *i.e.* almost parallel to the long axis of the chorion. Subsequently a portion becomes somewhat flattened or even depressed, and the cytoplasm thereabout becomes translucent in the form of an inverted cone. This portion begins to bulge out, and fifteen minutes later it finally assumes a spherical shape. This eventually separates from the mother egg, forming the first polar body. After the complete detachment of this body, the egg returns to its normal spherical form, and loses its transparency throughout its entire mass. Then ensues an interval of about thirty minutes ; after which the egg again behaves as above described. The new spherical structure or the second polar body is thrown out here very close to the first. After the completion of the maturation processes, the restoration of the egg to the normal spherical form is again effected. Generally fifteen minutes are required for each of the two processes:—the formation of the second polar body, and the restoration of the spherical form. Then follows a pause of one or more hours, after which the egg elongates for the third time. This is the preparation for the first cleavage. If we carefully observe the exact contour of the egg at this stage, we shall find that it is not strictly elliptical in shape. The portion which becomes the future posterior end is almost always slightly pointed. Hence, using an exaggerated expression, it may

be said to have an ovoid shape. The same state of affairs has been observed in *Limax* by MARK⁽³²⁾. Thus, before the cleavage process commences, it already shows a tendency to present inequalities in its two halves. After the elongation, a depression begins to appear in the animal pole near the polar body. It gradually extends downwards until it almost reaches the center of the egg. At about the same time a similar groove with a much sharper angle appears in the vegetative pole which proceeds upwards towards the center of the egg. (Fig. 5). The depression from the animal pole, however, proceeds much the more rapidly of the two until it reaches about the center of the egg. There it seems to stop, and to meet the approaching groove from the vegetative pole. Thus these two grooves encircle the egg leaving a bridge which for the time being connects the two halves. In the section, this bridge is proved to be the body of the spindle. This first cleavage plane is often described as moving directly from the animal pole to the vegetative in other species of Mollusca, for example, in *Umbrella* (HEYMONS)⁽²³⁾, *Unio* (LILLIE)⁽³¹⁾, *Succinea* (SCHMIDT)⁽³⁸⁾, *Limax* (MEISENHEIMER)⁽³³⁾, etc. In either case the cleavage results in the total division of the egg into two halves or blastomeres. The plane itself in *Siphonaria* stands almost transverse to the longitudinal axis of the future adult. The blastomeres thus formed seem at first sight similar in size; but a careful observation shows that in reality that carrying the polar body is a little larger than its complement. This difference in the size of the two halves is the consequence of the original inequality existing in the natural configuration of the egg before the cleavage. When the final constriction of the blastomeres takes place each of them has a spherical outline, not departing from it even at the point where they come in contact with each

other. When we observe a fresh specimen in such a stage, we notice the existence of a period, although very short, in which the two blastomeres are completely separated from each other by a narrow space. In *Limax*, KOFROID⁽²⁸⁾ claims to have found at the spot "a rather vague, transparent, and unstained protoplasmic connection." In my specimens, both fresh and preserved, I could not find any instance of such connection, although KOFROID's statement seems to be a highly reasonable one. The large blastomere thus formed contributes mostly to the formation of the anterior portion of the adult, while the smaller contributes to the posterior. Therefore, they will hereafter be designated respectively as the anterior and the posterior, blastomeres. The eggs of various Molluscan species which have been thus far studied are not alike in the size of the two blastomeres. For example, in *Unio* the posterior blastomere is larger, while in *Neritina* (BLOCHMANN)⁽¹⁾, *Umbrella*, etc. it is smaller than the anterior one.

Soon, the two blastomeres again come gradually in contact with each other, the surfaces by which they touch, becoming flattened. Simultaneously their general configuration begins to alter, and becomes somewhat elongated in the direction parallel to the plane of contact. During this period of apposition the anterior blastomere slightly shifts its position obliquely upwards in the direction of the animal pole. In about one hour, the blastomeres begin to stretch further in the direction already elongated and finally divide in a plane which is at right angles to the plane of contact or that of the first cleavage. This phenomenon appears usually first in the anterior one (Fig. 6), and is soon followed by the posterior complement. In the blastomeres thus transformed, the furrow causing the second cleavage commences almost simultaneously at the animal and the

vegetative poles. It stands almost at right angles to the first cleavage plane and coincides with the future median axis of the body. As a consequence the egg is subdivided into the right, and the left halves (Fig. 7). Concerning the priority of the cleavage in the first two blastomeres just described, there is much controversy. In *Umbrella*, *Aplysia*, and others the posterior blastomere divides first. On the contrary, in *Neritina*, *Unio* and others the anterior precedes the other. Thus it is easy to see that in Molluscan eggs the priority of cleavage is quite independent of the amount of the deutoplasm and its distribution in the egg.

The four cells formed by the second cleavage take a spherical form just as in the case of the first blastomeres, but soon become flattened on one side as the result of mutual contact. They, as a whole, constitute the first quartet and are commonly designated as *A*, *B*, *C*, and *D*, (Fig. 8) of which *A* and *B* come from the anterior, and *C* and *D* from the posterior, blastomeres of the two cell stage. During the formation, and especially during the accommodation of this quartet the cell *C* shifts its position obliquely upwards. At length, it comes to stand in the same level with the two anterior blastomeres leaving its complement cell *D* in the original level lower than the others. By this shifting it also happens that the two diagonally opposite cells *B* and *D* are brought in direct contact at the animal, as well as at the vegetative, poles, forming what has been called the cross furrow. The cells forming this furrow differ in different species, and sometimes the furrow is formed by different cells at the two poles. Moreover, there are many cases, in which the length and the direction of the furrow presents marked differences in these two poles. However, in the species under consideration, the furrow is formed by the juxtaposition of the same cells both in the

dorsal and the ventral views, and it has also the same length on both surfaces.

Aplysia :—The egg of this species when freshly deposited is at almost the same stage as that of *Siphonaria*. It has not yet discharged the polar bodies. The process of fertilization, however, shows no material difference from that of the preceding species. It is worthy of note that the polar bodies appear in the small cytoplasmic portion of the egg. After the polar bodies are completely formed the egg begins gradually to elongate and at last assumes an ovoid shape, the pointed end being toward the cytoplasmic portion. The first cleavage plane appears just as in *Siphonaria* from both the animal and the vegetative poles (Fig. 39). The result of this division is the formation of two blastomeres totally different in size as well as in quality (Fig. 40). The larger blastomere is heavily laden with deutoplasm; while the smaller one is almost wholly devoid of it. Such a striking difference in the two blastomeres is observed in only a few cases in Gastropoda even in the so called yolk-laden eggs, of *Umbrella*, *Planorbis*, etc. Of these two blastomeres the larger half represents the future anterior portion of the body, and the smaller half its posterior portion, these corresponding to the smaller and the larger blastomeres of *Siphonaria*. The further changes accompanying the first cleavage, such as the gradual and mutual accommodation of the blastomeres take the same course as in *Siphonaria* already fully described above. The second cleavage in this species takes place first in the posterior half (Fig. 41, Pl. II). The new cells thus generated are, as in the case of *Siphonaria*, designated as *A*, *B*, *C*, and *D* (Fig. 42). Their relation to the future axis of the body coincides with that of the former species and therefore requires no further explanation.

After complete accommodation it will be seen that here again the cross furrow lies between the cells *B*, and *D*, both at the animal and the vegetative poles. The same phase is observable in *A. limacina*,⁽²⁾ and also with only a slight difference in *Umbrella*. The hypothesis advanced by KOFOID,⁽²⁸⁾ as to the relation existing between the cross furrow and the presence of an abundant deutoplasm can not be accepted in these cases.

THE FIRST QUARTET OF ECTOMERES.

Siphonaria (a_1 , b_1 , c_1 , d_1 , Figs. 9-11, Pl. I):—About two hours after the complete formation of the original quartet, the spindles appear simultaneously in all the blastomeres; but actual cleavage begins always at the left posterior one *D*. The axes of the spindles in all the cells are directed obliquely upwards (Fig. 10), and when seen from the animal pole they seem to converge towards one another (Fig. 9). The cleavage proceeds in one cell after another in a certain regular course. In this species the course of this cleavage is in a right-handed spiral or in the direction of the motion of clock-hands as shown in Fig. 9, the apical view, and also in Fig. 10, the posterior side-view. In the former figure we see that the blastomere *D* precedes all others in development, presenting already its small daughter-cell. This priority of cleavage and the further course of development is made clear by the next figure. Here the first ectomere cell, d_1 from the blastomere *D* is seen to be already well formed, while the formation of a_1 from the blastomere *A* is not as much advanced. In the other two blastomeres *B* and *C*, the division is indicated only by a spindle. It is stated by KOFOID, that in *Limax* the

spindles gradually shift their positions during this cleavage. Such does not seem to be the case in *Siphonaria*: the axis of the spindle, as may be partly gathered from the figures cited above, remains unchanged in direction throughout the whole of this phase. The newly formed cells, however, moves lightly when they come to adjust themselves to one another. Four daughter cells a_1 , b_1 , c_1 and d_1 (Fig. 11) thus propagated form the first quartet of ectomere cells, lie, when completely detached, on the dorsal side of the mother-blastomeres. They are small in size and are at first merely an aggregation of spherical bodies, which however soon begin to be applied one against another. When finally settled, they seem to have been shoved somewhat towards the anterior end (Fig. 11). Now in this new quartet the cross furrow is again formed by a juxtaposition of the ectomere-cells b_1 and d_1 just as it was in the preceding stage by their mother-blastomeres B , and D (Fig. 11). Thus the furrow of the ectomere-cells and that of the blastomeres are formed by the cells genetically related to one another. The lines of these two furrows form a small angle with each other, *i.e.*, neither runs parallel with, nor stands at right angles to, the other as is the case in many other species.

Aplysia (a_1 , b_1 , c_1 , d_1 , Figs. 43–44, Pl. III):—The formation of the first quartet of ectomeres here also commences first in the posterior blastomere (Fig. 44), most usually from its left component D , and is followed immediately by the cells C , B , and A in the order named (Fig. 43). Thus the cleavage proceeds in a left-handed spiral, *i.e.* in the direction just the reverse of that of *Siphonaria*. This direction is contrary to that ascertained by BLOCHMANN in *A. limacina*, and also in other forms of yolk-laden egg noted by various authors. The first quartet of ectomeres formed are much smaller than the mother blastomeres; and when

finally settled, the position they occupy is on the posterior dorsal portion of the egg, instead of on the anterior dorsal as in *Siphonaria*. On the other hand the cross furrow keeps its relative position exactly as in the case of the preceding species (Fig. 45).

THE SECOND QUARTET OF ECTOMERES.

Siphonaria (a_2, b_2, c_2, d_2 , Fig. 12-13, Pl. I):—After a pause of about one hour, the second generation of ectomeres originates again from the original blastomeres. They arise first in the posterior blastomeres as in the case of the first generation, but this time from the right cell *C*. Although spindles often appear in all the blastomeres at the same time as shown in Fig. 13, yet the cell *C* is always ahead of all the others in actual cleavage. The order of division here is just the reverse of that in the first quartet as shown in Fig. 12, in which we notice that of the second quartet cells c_2, b_2 , and a_2 have already been produced, while *D* is just preparing to bud off d_2 . These ectomere-cells are of the same size as those of the first quartet, and roughly speaking occupy positions alternate with these latter.

Aplysia (a_2, b_2, c_2, d_2 , Figs. 45-47, Pl. III.) :—In this species too, the second quartet of ectomere-cells arise from the blastomeres, the process beginning as in *Siphonaria* from the right posterior one *C*. Cleavage, however, proceeds in a right-handed spiral, the reverse of the order in which the first generation was budded off. This point as well as the relative position of the newly formed generation are clearly illustrated in Figs. 45, and 46, which give respectively the apical and the left lateral, views of the egg. In Fig. 45 the spindles are seen in all the blastomeres except *B*, and that of *C* is most advanced. In the next

figure also, the order of cleavage is clearly indicated inasmuch as the blastomere *C* has already almost detached its new daughter cell *C*₂; and *D* is about to divide. In this species the second quartet of ectomere-cells are much larger than the first set and occupy positions alternate with these as in *Siphonaria*.

THE THIRD QUARTET OF ECTOMERES.

Siphonaria (*a*_{1,1}, *b*_{1,1}, *c*_{1,1}, *d*_{1,1}, Figs. 14-15, Pl. I):—In a majority of the Molluscan eggs direct segmentation from the blastomeres stops temporarily with the second quartet of ectomeres, the third being derived mostly from the first quartet of ectomere-cells. This is also the case in the present species. In my preliminary note on the development of the present species communicated to the Zoological Magazine already referred to, I noted that this generation also originates from the blastomeres. A renewed investigation has shown that this view was a mistaken one, having been caused by the abnormal condition of the specimens then accessible. In reality, this new generation arises from the first quartet of ectomere-cells. Cleavage begins from the first descendant (*d*₁) of the left posterior blastomere and proceeds in a right-handed spiral. In Fig. 14, the apical view of this stage, *d*_{1,1} alone has been budded off; while all the others show the spindle in a more or less similar state. These ectomere-cells of the third generation or trochoblast cells, as they are usually called, are smaller than any of the preceding generations. Nevertheless, they are rather conspicuous, coloring deeply when stained. They lie in the same level and in alternation with the ectomere-cells of the first quartet, pushing the cells of the second quartet (*a*₂, *b*₂ etc) to the left, in the order which indicates a

right-handed spiral. Such a displacement of the cells is recognizable when we compare Figs. 12 and 15.

Aplysia ($a_{2,1}$, $b_{2,1}$, $c_{2,1}$, $d_{2,1}$, Figs. 48-50, Pl. III):—In this species as well as in *A. limacina* the ectomere-cells of the third generation are not the descendants of the first quartet of ectomeres. Here it is the ectomere-cells of the second quartet, which present the spindles in a left-handed spiral, the right posterior cell c_2 taking the lead in cleavage. Fig. 48, the apical view, shows the priority of cleavage in the cell c_2 , although sometimes we meet with abnormal cases as represented in Fig. 49, in which the cell a_2 precedes the others in cleavage. The new daughter cells are similar in size to any of the preceding generations, and do not take a bright stain like those of *Siphonaria*. Again as they are the descendants of the second generation, they stand in alternation with the latter, and their positions with regard to the first generation are different from what is seen in the preceding species.

THE FOURTH QUARTET OF ECTOMERES.

Siphonaria (a_3 , b_3 , c_3 , d_3 , Figs. 15-16, Pl. I):—An hour or so after the last stage, the blastomeres again exhibit the spindles. This time the spindle appears first in the right posterior blastomere C , and the cleavage proceeds in a right-handed spiral. The period in which this generation arises seems to differ with species, as will be seen directly in the case of *Aplysia*. In the present species its formation commences somewhat later so that it appears concomitantly with that of the next generation. This is easily proved by referring to Fig. 15, the apical view, and Fig. 16, the sagittal section seen from the left side. In the former,

all of the blastomeres except *D* are shown to have budded off their daughter cells c_3 etc.; while in the latter which represents a slightly earlier stage the blastomeres of which *A* and *D* are seen show their spindles in an early phase. It is moreover evident in both the figures, that the formation of this generation is immediately followed by that of the fifth quartet ($a_{2,1}$, etc). The cells of the fourth generation are, as a rule, rather larger than any of the foregoing ones. They occupy a position on the ventral aspect of the egg, just under the third generation ($a_{1,1}$, etc). By the formation of the fifth generation they, however, shift their position more to the left side; and eventually come to interpose themselves together with the fifth quartet between the cells of the second (a_2 , etc) generation (Fig. 15).

After throwing off three series of ectomeres, *i.e.*, at the formation of this fourth generation of ectomeres the blastomeres are completely differentiated, and make no further contribution to the formation of the ectomere-cells. The cleavage which occurs later in the blastomeres gives rise to the generations of entomere-cells. Hence, the blastomeres receive the name of entomeres with the single exception of the left posterior one *D*. This latter ultimately gives birth, beside the entomere, to the mesomere, so that it is generally designated as the ento-mesomere.

Aplysia (a_3 , b_3 , c_3 , d_3 , Figs. 48–50, Pl. III):—The fourth generation arises as in *Siphonaria* from the left posterior blastomere, and proceeds in a right-handed spiral. In this species too, as was mentioned in *Siphonaria*, the formation of this generation very often takes place simultaneously with that of another quartet, but here it is with the preceding (c_2 , etc), and not with the following, generation. This fact is well illustrated in Figs. 48 and 50, respectively showing the apical

view, and the sagittal section seen from the right side. The ectomere-cells of this generation are a little larger than any of the preceding. When fully adjusted (Fig. 51), they take their positions, as in the first species interposing themselves between the cells of the second (a_2 , etc) and the third ($a_{2.1}$, etc) quartets. In this species also, this generation is the final ectomere product from the blastomeres. Henceforth, the blastomeres are called entomeres or ento-mesomere according to their characters just as in *Siphonaria*.

At about this time a noticeable change occurs with regard to the relative positions of the anterior and the posterior entomeres. By the repeated cleavage already gone through, it is seen that the posterior half is gradually brought upwards toward the apical pole. This shifting increases with development and is combined with a slight movement toward the right side. If we refer to Fig. 44 a right lateral view of the blastomere stage, and to Figs. 46 and 49, representing the posterior views of the different stages, one before the formation of the second generation, and the other after the formation of the third generation, we can easily comprehend the above mentioned change in the cell arrangement. At the outset both the anterior and the posterior, halves of the egg stand almost on the same level (Fig. 44). By two consecutive cleavages of the first and the second quartets of ectomeres, the posterior half has shifted its position almost half way up the anterior components (Fig. 46). Finally the former seems to stand high up, and to surmount, the latter. That there is at the same time a slight shifting toward the right is seen by comparing Figs. 46 and 49. In the former the plane of contact of *A* and *B* is seen through the right portion of *D* and near the contact plane of *D* and *C*. In Fig. 49 the latter contact plane

is much further to the right. Moreover, it is to be observed that the difference in the amount of cytoplasm contained in the anterior and the posterior halves of the egg causes the gradual displacement of the ectomeres in general toward the posterior end. This seems to be due partly to the fact that during all the cleavage processes the axes of the spindles in the anterior blastomeres always have a tendency to be inclined toward the posterior end, so that an ectomere-cell budded off generally lies dorsally and *posteriorly* to its mother cell. The posterior position of ectomeres is marked even from the stage of the first ectomere generation; thus in Fig. 45 which shows the first quartet of ectomeres in their proper position we see how they lie more on the posterior blastomeres. The same arrangement is also continued up to quite late stages. Although this tendency is noticeable in other yolk-laden Molluscan eggs it does not seem as pronounced as in *Aplysia*, for their blastomeres shows no such marked difference in nature as there is in this species.

THE FIFTH QUARTET OF ECTOMERES.

Siphonaria ($a_{2,1}$, $b_{2,1}$, $c_{2,1}$, $d_{2,1}$, Figs. 15-16, Pl. I):—As I have already stated the formation of this generation takes place in conjunction with the preceding one. It arises from the second quartet of ectomeres. As is seen in Fig. 15 the cleavage makes its first start from the right posterior cell c_2 and its course is in a right-handed spiral. The daughter cells $c_{2,1}$, etc thus formed are as large as those of the fourth generation. They are situated more ventrally than the mother cell and finally interpose themselves between the cells of the preceding generation, pushing the latter more to the left along the right spiral. From this time

onward it gradually becomes evident that all the generations of the ectomere-cell, as a whole, make but a slight displacement compared with what is generally seen in other species. They do not strictly overlay the entomeres; but lie toward the anterior, and not toward the posterior, end as was the case in *Aplysia* already alluded to.

Aplysia ($a_{1,1}$, $b_{1,1}$, $c_{1,1}$, $d_{1,1}$, Figs. 51-52, Pl. III):—In *A. limacina* this generation is said to be propagated from the third quartet of ectomeres; but in this species it is descended from the first set of ectomeres. Cleavage begins with the cell c_1 and its course is in a left-handed spiral. In Fig. 51, representing the apical view of such a stage, the new ectomere-cell $c_{1,1}$ is seen to have been completely budded off from its mother-cell c_1 and to have already assumed the normal form; while in all of the other quadrants the spindle remains in the amphiasier stage. The same phase in the posterior two cells of the first ectomere-quartet is also recognizable in the optical transverse section seen from the posterior side (Fig. 52). The new ectomere-cell or the trochoblast is very much smaller than any of the foregoing ectomeres as in the case of *Siphonaria*. However in its general outline and in its reaction toward the staining fluids it bears a great similarity to the third quartet of ectomeres in *Siphonaria*, so that its recognition is a matter of considerable ease. The resemblance of these two generations of ectomeres in the two species is intelligible when we remember that they are both the first direct descendants of the first generation of ectomeres and thus have the same genealogical history. The fifth quartet of ectomeres occupies a position always ventral to its mother-cell and lies almost exactly on the ectomere-cells of the third generation. It also interposes itself between the ectomere-cells of the second generation.

THE SIXTH QUARTET OF ECTOMERES.

Siphonaria ($a_{2,2}$, $b_{2,2}$, $c_{2,2}$, $d_{2,2}$, Figs. 17–19, Pl. I):—The origin of this generation presents much variation according to the species studied. In *Siphonaria* it again arises from the second quartet of ectomeres. Here the cleavage takes place first in the right posterior cell c_2 followed immediately by the cell b_2 , a_2 , etc., thus taking the course of a left-handed spiral. Fig. 17 illustrates a horizontal section of this stage, in which all the ectomere-cells of the second generation show their spindles. By the segmentation of this stage, the ectomere-cells of the second quartet are divided into two cells of unequal sizes. The newly formed daughter-cell $a_{2,2}$, etc. is smaller than its mother-cell; but it comes to occupy the position originally occupied by the latter. As a consequence, the mother-cell shifts its position ventrally toward the right side, and at length rests on the cells of the fourth and the fifth generations. In this stage or sometimes somewhat later, there takes place a noteworthy event, viz., the cleavage of the entomesomere D (Fig. 18). The spindle lies in the lower anterior part of the cell so that it is easily seen in the horizontal and the sagittal sections, Figs. 18 and 19. The cleavage is soon followed by the division into two cells, the entomere-cell D_1 , and the mesomere-cell M (Fig. 20). They present considerable differences not merely in size, but also in general character. The entomere-cell D_1 is of about the same size as the ectomere-cell of the third quartet, and moreover like the latter has a comparatively large nucleus. It is situated anteriorly, ventrally to the mesomere-cell M , (Fig. 21) and maintains its direct contact with the right anterior entomere B , with the cross furrow between as before

(Fig. 20). The mesomere-cell, on the other hand, is large, and translucent, and now comes to occupy a position almost in the median axis of the egg.

Aplysia ($a_{2,2}$, $b_{2,2}$, $c_{2,2}$, $d_{2,2}$, Figs. 53-55, Pl. III):—Yolk-laden eggs of Mollusca present much difference in the origin of the present quartet of ectomeres. In *Umbrella* it arises from the third generation and in *Neritina* from the fifth. In the species of *Aplysia* other than the one studied in the present investigation, this generation is described as arising from the fourth quartet of ectomeres. In the present species, however, it is the outcome of the second generation just as in *Siphonaria*; and the course of cleavage is likewise quite identical in both cases. The spindle in the ectomere-cells of the second quartet lies almost horizontal, so that the daughter-cells $a_{2,2}$, etc. stand at the same level with their mother-cells; and when fully accommodated they push the ectomere-cells of the fifth generation to the left, finally interposing themselves between these latter and the mother-cells. Fig. 53, the optical horizontal section from the animal pole shows that the right posterior cell c_2 of the second generation of ectomere-cells has already propagated its new daughter-cell $c_{2,2}$; while its left component d_2 still presents a spindle. From this the course of cleavage and the relative position of this new series of daughter-cells will be easily comprehended. In this figure it will also be seen at a glance that the formation of the ectomere generations no longer follows with a strict regularity as in earlier stages, and spindles are present simultaneously in cells other than the second quartet of ectomeres. Such an irregularity in cleavage is also seen in Fig. 54, the optical sagittal section near the median line, the division of two consecutive sets of ectomeres here arising almost at the same time.

THE SEVENTH QUARTET OF ECTOMERES AND THE CHANGE
FROM THE RADIAL TO THE BILATERAL, SYMMETRY.

Siphonaria ($a_{2.1.1}$, $b_{2.1.1}$, $c_{2.1.1}$, $d_{2.1.1}$, Fig. 20, Pl. I, and Fig. 21, Pl. II):—The seventh quartet of ectomeres is the first descendant of the fifth quartet ($a_{2.1}$, etc.). In Fig. 20, a horizontal section near the vegetative pole, the first cell $d_{2.1.1}$ of the new generation is quite detached from the left posterior cell $d_{2.1}$ of the fifth generation, which, however, is not seen in this figure being situated more dorsally. Cleavage proceeds in a right-handed spiral. The daughter-cell is quite similar in its general character to the cells of the third, and the sixth generations. It lies ventral to the mother-cell, and ultimately assumes a position alternate with the cells of the fourth generation a_3 , etc. (Fig. 24). From this time on until the differentiation of the three germinal layers none of the cells at the vegetative pole of the egg presents any marked change. The vegetative pole is occupied by the entomeres A , B , C , D , and the mesomere M surrounded by the ectomere-cells of the fourth (a_3 , etc.) and the seventh ($a_{2.1.1}$, etc.) generations (Figs. 20 and 24).

Up to the present stage each of the successive generations of ectomeres has invariably been formed of a quartet, the cells of which are produced in a certain regular way, and keep their relative positions in a spiral form. Such a disposition of cells is generally known as the spiral symmetry. This form of symmetry is, however, generally not retained after the formation of the mesomere-cell M , and is eventually changed into a bilateral symmetry. This, so far as I am aware, is said by investigators to be caused, in most of the Molluscan eggs simply by the new posi-

tions taken up by that quartet of ectomeres which are produced as the first descendant of the fourth generation. Subsequently, all the cells come by degrees to shift their positions so as to accommodate themselves to this new generation. Thus the egg has been said to ultimately assume a bilateral symmetry, and as this takes place only very gradually, it is said that it is sometimes quite impossible to point out with exactness the transitional stage. In *Siphonaria* this phenomenon happens at, or a little after, the stage in which the seventh generation of ectomere-cells has been budded off. The alteration of the body-form is in this species also induced by the same generation of ectomeres that causes the change in the other species alluded to above (*viz.* the first descendant of the fourth generation); but what I make out respecting its formation and disposition is totally different from what has hitherto been stated. *The two posterior quadrants of the fourth ectomere-quartet (e_3 and d_3), adjoining laterally the mesomere-cell M begin to present the spindles (Figs. 20 and 21), the left component (d_3) taking the lead. Unlike all others these spindles lie in a strictly radial and horizontal direction. Consequently the daughter-cells, lc and rc when divided, come each to occupy a position more median than that of the mother-cell, close to the sides of the mesomere-cell M and also they are in exact bilateral symmetry with regard to each other (Figs. 24 and 25). They are quite like the ectomere-cells of the seventh quartet in size as well as in general appearance. The two anterior quadrants a_3 and b_3 of this fourth generation, which are so often described as dividing almost synchronously with, or a little later than, their posterior component cells, never present in this species any trace of a spindle until after the complete differentiation of the germinal layers. On account of*

this highly specialized method of the formation and characteristic disposition of the cells, such as has not yet been described in other species, I think it is better to denominate these as the *bilateral* cells, thus distinguishing them from other ectomere-cells. With the birth of the bilateral cells the spiral symmetry is materially and abruptly disturbed; and the configuration of the egg is at length completely transformed into a bilateral symmetry. Thus it is seen that the change of the symmetry takes place in this species at a period more definite than in any others thus far known to us.

Aplysia ($a_{2.1.1}$, $b_{2.1.1}$, $c_{2.1.1}$, $d_{2.1.1}$, Fig. 54–55, Pl. III):—In *Aplysia* the seventh quartet arises from one different in order, but of strictly the same genealogical derivation as the corresponding one of the foregoing species. Here it arises from the third generation, and indeed first from its left posterior-cell $d_{2.1}$, thence following the left-handed spiral. This state of things will be fairly understood when we compare Figs. 54 and 55, illustrating the sagittal, and the horizontal, optical sections respectively. In these two figures the ectomere-cell $d_{2.1}$ alone is represented. It is noteworthy that while the spindles of the cells heretofore described as well as of the other quadrants of this same quartet ($a_{2.1}$, etc.) lie almost horizontally the spindle in this cell is seen to take a somewhat vertical position. Consequently, when the new daughter-cell $d_{2.1.1}$ is budded off, it lies more ventrally than the other quadrants $a_{2.1.1}$, $b_{2.1.1}$, etc. The daughter-cells thus generated have a great similarity in general outline to those of either the fifth, or the sixth generations. They generally border the ventral side of the egg, lying almost under the cells of the second generation.

Concomittantly with this stage or a little earlier (Figs. 53

and 54), there takes place the differentiation of the ento-mesomere cell D . This often happens as early as the stage of the sixth quartet, as is shown in Fig. 54. The details of this event are quite like those of *Siphonaria*, and therefore need no further explanation. Even the entomere-cell D_1 itself thus formed, is like that of the former species. It lies anteriorly and ventrally to its mother-cell or mesomere M , and of course has the cross furrow in its original relation.

Besides this notable phenomenon there always ensues still another remarkable change in the process of cleavage, namely the formation of the bilateral cells similar to those described above in *Siphonaria*. The division of these new daughter-cells is quite similar to what takes place in the species just cited. The two posterior ectomere-cells of the fourth generation e_3 and d_3 adjoining the right and the left sides of the mesomere-cell M now begin to divide quite independently of their two anterior companions. As is well shown in Fig. 53 an apical view of the animal pole, the spindles in these two cells lie almost horizontally and are directed, unlike all the preceding ones, toward the median axis, that is, in a somewhat radial direction. The spindle usually appears first in the right cells e_3 (Fig. 55), and produces a small daughter-cell re (Fig. 56) which resembles an ectomere-cell of the seventh generation, especially $d_{2,1,1}$ in its general appearance. The division of the left cell d_3 soon follows, producing the cell le . Although the two bilateral cells le and re are propagated from the cells of the same generation they behave in a slightly different manner. The left bilateral cell le at the beginning of its detachment lies very close to, or even in contact with, the entomere-cell D_1 (Fig. 56). Subsequently, by the cleavage of the mesomere-cell it is at last brought more toward

the posterior portion of the body so as to lie almost on the same level with its complementary cell *re* on the opposite side. By comparing Figs. 56 and 57, the optical horizontal sections of two different stages, we are able to perceive this change in the position of the left bilateral cell. Thus it seems that the final position of the bilateral cells in the two species under consideration coincides in almost every respect. I am not in position to contradict the views expressed by previous authors, concerning the transition from the radial to the bilateral symmetry; but at least in the species that I have studied I am convinced that the bilateral cells are the main, if not the sole, cause of the transformation of the body symmetry. I should like to make a remark here on the same stage in *A. limacina* BLOCHMANN makes no allusion to the phenomenon mentioned above. But a close inspection of his figures shows us the occurrence of the same events in that species. His Fig. 13 has an intimate relation to the stage of the seventh ectomere generation, although it is introduced to show an earlier stage. There it is seen that c_2 has given rise to a small cell. This does not seem to form a quadrant of a quartet, but corresponds in its general character to the left bilateral cell. Again in his Figs. 14 and 15 the cell c_2 as well as the first entomere-cells are seen to occupy the same position with those noted above by me. Although it is to be gathered from the author's interpretation that the change of the body symmetry occurs as early as the stage of about 24 cells, yet his figures incline me to believe that this phenomenon takes place much later, just as in the case of the present species.

Immediately after the formation of the bilateral cells or sometimes simultaneously with it there takes place the cleavage of the mesomere M. A spindle appears lying in the transverse

direction (Fig. 56), and subsequently divides the cell into two almost equal halves. The daughter-cells (m , Figs. 57 and 58) are ovate in form and are characterized by their less granular contents. Their position is in a strict bilateral symmetry with respect to each other, and the plane in which they come in contact almost coincides with the future median axis of the body.

Previous to this stage the nuclei of the entomere-cells A , and B lie usually near the posterior end in the middle line of each cell as is shown in Fig. 55. They, however, have commenced to shift their position toward the right (Fig. 56). This goes so far in A that the nucleus reaches the ventral side of the anterior end as will become intelligible by a reference to Figs. 56 and 58. It would seem that such a shifting of the nucleus in the two entomeres could have no other purpose than to prepare for the formation of the future entoderm-cell. This latter event arises shortly after the bilateral symmetry becomes well pronounced by the cleavage of the mesomere-cell M . The formation of the entoderm-cells has its beginning in the posterior cells; and indeed in the right component cell C (Fig. 57). In the formation of this generation the spindle lies almost horizontally, and the daughter-cells detached which are known as the entoderm-cells (A_1 , B_1 , C_1 , Figs. 59 and 60) are rather small and situated alternately with, and outside of their mother-cells (A , B , C).

THE EIGHTH QUARTET.

Siphonaria ($a_{1,2}$, $b_{1,2}$, $c_{1,2}$, $d_{1,2}$, Figs. 22-24, Pl. II):—With the differentiation of the entomere-cell D_1 the behaviour of individual cells becomes hardly ascertainable in a surface view.

The formation of this generation was therefore made out in *Siphonaria* from sections. In this species the first ectomere generation gives birth to the eighth quartet of ectomeres (Fig. 22), the right posterior cell c_1 taking precedence over the others. The spindles lie in rather a horizontal plane (Fig. 23), and the course of the division is in a left-handed spindle. The newly formed cells $a_{1,2}$, $b_{1,2}$, etc., which are shown in the next Fig. 24, are much larger than their mother-cells a_1 , b_1 , etc., with which they lie on the same level and the same radii. After this cleavage the first ectomere generation takes the shape of a rosette, the cross furrow being almost obliterated. At this stage the normal and typical form of the egg is rather oval in a horizontal view, narrowing toward the posterior side (Fig. 27). In a side view, however, it takes a wedge shape with the thicker end turned also toward the posterior side. About this time the ectomere-cells lose their spherical contour, and losing their individuality become more or less flattened, altogether presenting the appearance of a layer (Fig. 26). Hence they will hereafter be called the ectoderm-layer. The ectoderm is, moreover, disposed more or less in different zones. Fig. 24 illustrates the egg in this stage, which is seen from the apical pole showing clearly the exact positions as well as the mutual relations of the cells. The highest or dorsal zone is occupied by the first (a_1 , b_1 , etc.), the third ($a_{1,1}$, $b_{1,1}$, etc.), and the eighth ($a_{1,2}$, $b_{1,2}$, etc.) generations of ectoderm-cells, and the ventral zone (Fig. 25) is formed of the fourth (a_3 , b_3 , etc.), and the seventh ($a_{2,1,1}$, $b_{2,1,1}$, etc.), generations of ectoderm-cells and the entomere-cells (A , B , C , D_1), together with the bilateral cells (rc and lc) and the mesomere-cell M ; while the lateral zone is bordered with the ectoderm-cells of the second (a_2 , b_2 , etc.), the fifth ($a_{2,1}$, $b_{2,1}$, etc.), and the sixth ($a_{2,2}$, $b_{2,2}$, etc.), generations.

A similar but slightly advanced stage in *Aplysia* is also shown in Fig. 59. In this it is seen that unlike *Siphonaria* the first (a_1 , b_1 , etc.), the second (a_2 , b_2 , etc.), the fifth ($a_{1.1}$, $b_{1.1}$, etc.), and the sixth ($a_{2.2}$, $b_{2.2}$, etc.), generations of ectoderm-cells cover the dorsal apex of the egg. Furthermore the ectoderm-cells, as a whole, are aggregated in this species in a more posterior portion of the egg than in *Siphonaria*. Again, owing to the large size of the anterior entomeres the egg of *Aplysia* is generally thicker in that portion than is the case in the preceding species (see Fig. 54). Although not as marked as in other species, the first Anlage of the trochoblast-cells can be distinctly made out in the two species under consideration. As will be seen clearly in Figs. 24 and 59 the apical quartet of the first ectomeres is encircled by a girdle of eight cells, of which four ($a_{1.1}$, $b_{1.1}$, etc.), *i.e.* the first descendants of the first ectomere-quartet form the trochoblast. While the apical quartet gives rise to the "arms of the cross" its further development does not take place in these two species until after three germinal layers are firmly established.

In *Siphonaria*, after such a disposition of cells has been completed, the cleavage of the mesomere M and of the entomeres A, B, and C occurs synchronously (Fig. 25). Usually, however, the mesomere-cell M precedes the other three, as shown in the horizontal section (Fig. 25). The spindle in this cell is directed almost exactly horizontally (Fig. 26) and the cleavage plane thus formed comes to correspond with the median axis of the egg. The resultant cells (m) are in their nature quite identical with those of *Aplysia* to which allusion has already made (p. 25). It suffices here only to call attention to figures mentioned above, and to Fig. 27, which shows the horizontal section through the

middle portion of the egg. This latter is intended to illustrate the mesomere after its complete division into two daughter-cells and after their full accommodation. The three entomere-cells *A*, *B*, and *C* now commence to divide as in Fig. 25. In this case their nuclei do not show any shifting, such as was seen in *Aplysia*. The entomere-cells are divided into two halves almost equal in size; and all are arranged on the same level. From this time onward the entomere-cells dispose themselves in a layer and may now be called the entoderm-layer.

The further developmental course of the germ-layers has been studied with some degree of exactness only in *Siphonaria*. The ectoderm-cells gradually begin to divide indiscriminately; and hence it is wholly impossible to trace them in surface views beyond the tenth generation. The ninth quartet ($a_{2.2.1}$, $b_{2.2.1}$, etc.), arises from the sixth generation of ectoderm-cells ($a_{2.2}$, $b_{2.2}$, etc.), and the tenth ($a_{2.1.1.1}$, $b_{2.1.1.1}$, etc.), from the seventh ($a_{2.1.1}$, $b_{2.1.1}$, etc.), (Fig. 30). In what quadrant they first appear, and how the courses of cleavage run are quite uncertain. The new daughter-cells are always as small as their mother-cells.

The entoderm-cells go through their second cleavage, at the same time with the second division of the mesoderm-cells. This process begins with the cell A_1 and proceeds in a right-handed spiral, as seen in Fig. 34, a horizontal section of this stage, in which A_1 and B_1 have given off respectively $A_{1.1}$, and $B_{1.1}$, and C_1 shows a spindle. The small daughter-cells thus produced exactly alternate in position with their original mother-cells. The subsequent growth of the entoderm-cells seems very slow, and I have not traced it beyond this stage. I will only add here that the first entoderm-cells retain their original relative positions for a long time as indicated by the persistence of the cross furrow.

In fact it remains unchanged until the cells enter into the permanent portion of the alimentary canal. Hence it is of great use in determining the orientation of the body.

As to the mesoderm, its formation may be followed up to a certain stage with some exactness. After the eighth ectomere stage each of the two daughter mesomere-cells m come to present the spindle. It is directed obliquely forward and upward (Fig. 28), and appears first most frequently in the left component (Fig. 29). The daughter-cell or the first mesoderm-cell m_1 is very small; but its presence is easily recognizable owing to its large nucleus (Fig. 30). The second mesoderm-cell originates from the mesomere-cell as did the first. The fact is shown in the horizontal section Fig. 32, and the sagittal section Fig. 33. This, however, happens much later in time when there has already been much increase in the number of the ectoderm-cells. The new mesoderm-cell m_2 is much like the first one but it takes a position more ventral than the latter. The exact seat of these cells is clearly indicated in Fig. 36, a sagittal section of the egg. The third mesoderm-cell m_3 is now derived from m_1 beginning with the right component. It is the most dorsally situated of all as is shown in Fig. 35, a transverse section through the posterior side of the egg. The first mesoderm-cell soon again subdivides, thus giving rise to the formation of the fourth one m_4 . Fig. 36 just mentioned above also shows this fact, the spindle in the first mesoderm-cell m_1 being in the amphiaser stage. The mesoderm-cells, henceforth, seem to segment rather rapidly with no apparent regular order. At first they all aggregate as a mass in the posterior median line of the body. Gradually, however, they begin to spread toward the lateral parts, where they soon arrange themselves in distinct layers. In some other species of Mollusca the so called "larval

or secondary mesoblast" is often described as being formed from one or other of the ectoderm-cells, and it is supposed to contribute toward the formation of the mesenchyme. In the present species I was not able to find any trace of it so far as the investigation extended.

Several years have elapsed since I carried out the above investigation, and during that period, the investigations by WIERZEJSKI, MEISENHEIMER, HEATH, HOLMES, CARAZZI, GEORGEWITCH etc. on similar subjects have been published. Generally speaking, they have tended to confirm and verify the propositions that had already been made known by previous authors. I consider it advisable to refer to some of these works which bear directly on what I have described above.

In January 1900 there appeared a paper on the development of *Aplysia limacina* by CARAZZI, and again eight months after another paper by GEORGEWITCH on *A. depilans*.

CARAZZI has carefully traced out all the developmental processes up to the formation of the mesoderm-layer noting the time exactly. When we compare his results with those given above, it will be seen that they agree in the main. Nevertheless, there are discrepancies on some important points which cannot be passed without a word. The differentiation of the germ-layers in general is reached a little earlier in our species than in that studied by the Italian author, excepting the formation of the entomere D_1 , which is far earlier in his species. In his Fig. 2 we see the illustration of an egg from its apical pole, which coincides with Fig. 53 of the present paper. But one of

the drawings in his Fig. 3 (illustrating the vegetative pole of the egg) which is like my Fig. 57, is interpreted in a different way. The bilateral cell, to which I have called attention, is in our species produced at about this time from the posterior half c_3 and d_3 of the fourth generation of ectomere-cells. Such a cleavage really occur also in *A. limacina*; but it is said to be accompanied ordinarily with the simultaneous division in its anterior components. Hence, in that species the new generation is formed of a quartet like all the preceding ectomeres and does not influence in any way the transformation of the cell-arrangement. Nevertheless the bilateral form of cleavage occurs also in the ectomere-cells $3c^1$ and $3d^1$, as may be gathered from the author's own words as "subito dopo, alla 28^a ora $3c^1$ e $3d^1$ si dividono con fusi trasversali, cioè con divisione bilaterale, mentre $3a^1$ e $3b^1$ rimangono in riposo." However, this is the second division of those ectomeres, and indeed after the bilateral symmetry is fairly established by the formation of the mesomere-cell. Thus the transformation of the body symmetry here seems to be effected by the gradual and renewed disposition of already formed ectomeres rather than by a single cleavage of the posterior half of the fourth ectomeres. Such a method of transformation is seen in various species as I have already noted.

Concerning GEORGEWITCH's paper on *A. depilans* the author, it appears to me, has fallen into some confusion on important points. At all events his ideas on the orientation of the egg are exactly contrary to those usually held, the portion called by him the posterior, being really the anterior, so that his "Urmesodermzell" is in fact derived from the anterior blastomere. And it is very strange that he describes the posterior (really anterior) half of the second quartet of ectomeres as the "Ur-

mesomere." By my investigation given above as well as by those of others it is known that this generation is the most active in its growth, at least before the establishment of a bilateral symmetry. They ought to have given rise to daughter-cells before the true mesoderm "*Kleine Zelle m*," was first perceived by the author. By a careful study, however, I have at last found that his description and figures do not harmonize. In his description not a word is said as to the fate of his anterior blastomeres *A* and *B* *i. e.* really the posterior *C* and *D* of authors. But we can ascertain from his Fig. 20 that these cells segment almost at the same time. In short, according to his paper we must finally arrive at the very embarrassing conclusion that he has put three totally different kinds of cells under one and the same name of "the mesoderm" viz., (1) the descendants of the second ectomere-cells or according to the author *2c* and *2d* (Fig. 10), and (2) the descendants of the entomere *C* or according to the author *m*, in addition to (3) the descendants of the proper mesomere, which seems to have been entirely overlooked by the author. Yet these cells, as they represent the ectomere-, the entomere-, and the mesomere-cells ought not of course to be confounded. This and some other conclusions of the author, which I can not help considering as too hasty are derived from his assumption of the homology existing in the formation of the original mesomere-cells in the species in question and in Polyclads. The fact is clearly seen in his own term—"Der Ursprung und die Lage dieser 2 Zelle *m* und *m*₁ stimmt so auffallend mit denjenigen bei Polycladen überein,....."

In the same year a paper entitled "The Early Development of Planorbis" was made public by HOLMES. By a careful study of this author new light has been thrown on many points,

especially concerning the fate of the cells. Nevertheless the alteration of the body-form in this species seems to be not so pronounced as in those I have studied. HOLMES seems to think that the ultimate cause of such a transformation lies in the different behaviour of the posterior cells of the third ectomere generation. Thus he goes on to say:- "we may view the earlier division of the cell 3a and 3b as the first foreshadowing of bilateral cleavage." By this expression it is quite evident that there is no special cell formation as in the cases described in the present paper. Such a gradual modification as is elucidated by the author is of a wide occurrence in the Molluscan egg and the change of symmetry by the cell formation near the posterior end of the body is demonstrated at present only in the species studied by myself. Nevertheless I believe that the same fact will hereafter be confirmed in other forms.

It may not be useless to summarize here the main points brought out in the present investigation.

1. Throughout the whole process of cleavage it is observable, that there is no fixed regularity in the course such as is expressed in the so-called law of alternation of spirals as stated by WILSON, KOFOID *et al.* Even the corresponding daughter-cells from the same blastomeres or ectomere-cells are propagated differently in different forms. The first generation of ectomere-cells is produced in *Siphonaria* and in *Aplysia* in spirals of opposite directions and even in the same species the cleavage sometimes takes place consecutively in the same direction, and not alternately to right and to left as has been observed in other forms.

Nevertheless, it should be borne in mind, that cleavage commences invariably from one or the other of the posterior blastomeres or its descendants.

2. After the second cleavage the opposite quadrants of the blastomeres usually come in juxtaposition forming the cross furrow between. KOFOID has made the statement that the quadrants forming the furrow at the two opposite poles differ with species according to the amount of the deutoplasm in the egg. This does not hold good at least in the present cases. *Siphonaria* and *Aplysia* perhaps represent two extremes with regard to the quantity of the deutoplasm. Nevertheless, as has been seen, the cross furrow in these two species is formed at both poles by the same quadrants.

3. During the cleavage of the egg, the daughter-cells are disposed in a spiral form, that is, the individual cells shift their respective positions either toward the right or the left of their original positions. Such a spiral arrangement or symmetry is retained for some time. It is then abruptly transformed into a bilateral symmetry. This important phenomenon, so far as I am aware, has been interpreted as due to the rearrangement of the component cells. It is true that in an advanced stage the disposition of the cells becomes altered; but there is another important factor which necessitates such a transformation of the body symmetry. The factor is the existence of certain new cells propagated from the fourth generation of ectomere-cells. Of the quartet which forms this generation, the two posterior cells give rise in a peculiar way to the daughter cells which I have called the *bilateral* cells. These play an important rôle in bringing about the change of the body symmetry, which seems to take place in a comparatively short space of time. The period of

his change is, as WILSON remarks, after the entomere-cell differentiates itself from the left posterior ento-mesomere-cell, and takes its seat along the median axis. In other words, the bilateral symmetry appears just after the cells of the three germ-layers are distinguished. This corresponds with the stage when the sixth or seventh quartet of ectomeres is formed and the egg is composed of 29-33 cells as is shown in the tabulated form below. The exact period of the occurrence could not be expressed as it varies with the species, and even in the same species with the environment.

4. The cleavage of the mesomere-cell takes place after the bilateral symmetry is completely established. It is then subdivided into two equal halves, which stand in a strict bilateral symmetry with regard to the median axis. Shortly afterwards from each of these cells mesoderm-cells are propagated, which by the further division eventually form a layer. Hence, it is clear in these species that the mesoderm-cells take their first origin from the posterior quadrants of the blastomere as in many other species. The differentiation of the three germ-layers strictly speaking dates from the formation of the mesoderm-cells. It is at about the stage of the eighth generation of ectomere-cells in *Siphonaria* and of about the tenth generation in *Aplysia*. It is therefore the 42-cells stage in the former, while it is the 50-cells stage in the latter. Thus, the differentiation of the mesoderm-cells varies in time not only in the species named above, but also in all those forms before thoroughly investigated. The results of the present investigation as well as of those of other authors are compiled below in the form of tables to facilitate a comparative study of the Molluscan development:—

Tables showing the cell-lineage in Molluscan Egg.

b.c.....bilateral-cell

d.....entomere-cell

ent.....entomere-cells excepted

M.....mesomere-cell

m.....mesomere-cell segmented

m₁, m₂, etc.....mesoderm-cells

n.....generation of ectomere-cells

I SIPHONARIA

		Order of Quartet									
		I	II	III	IV	V	VI	VII	VIII	XI	X
Egg	Blastomere	n ₁		n _{1,1}							
			n ₂			n _{2,1}			n _{1,2}		
					n ₃		n _{2,2}	n _{2,1,1}			
								(b,c)			n _{2,1,1,1}
							(M) (d)		(m) (m ₁) (ent.)	n _{2,2,1}	(m ₂)
No. of Cells	4	8	12	16	20	24	29	35	43	47	51
Time	7 hours	8	9-10	11-12	13-15	18-19	20	21-22	22	24	26

II APLYSIA

		Order of Quartet									
		I	II	III	IV	V	VI	VII	VIII	IX	X
Egg	Blastomere	n ₁				n _{1,1}					
			n ₂			n _{2,1}			n _{2,1,1}		
					n ₃		n _{2,2}				
								(b,c)			
							(M) (d)		(m) (ent.)		(m ₁)
No. of Cells	4	8	12	16	20	24	31	39	43	47	51

III NERITINA (Blochmann)

		Order of Quartet									
		I	II	III	IV	V	VI	VII	VIII	IX	X
Egg	Blastomere	n_1		$n_{1,1}$							
			n_2			$n_{2,1}$	$n_{2,1,1}$				
					n_3			$n_{3,1,2}$		$n_{3,1,1,1}$	
									$n_{3,1}$		$n_{3,2}$
										{ (M) (d)	
										(ent.)	(m)
No. of Cells	4	8	12	16	20	24	28	32	36	44	50

IV UMBRELLA (Heymons)

		Order of Quartet									
		I	II	III	IV	V	VI	VII	VIII	IX	X
Egg	Blastomere	n_1			$n_{1,1}$			$n_{1,1,1}$			
			n_2			$n_{2,1}$					
				n_3						$n_{3,2}$	
							$n_{3,1}$		$n_{2,2}$		
							{ (M) (d)		(m)		
										(m ₁) (ent.)	
No. of Cells	4	8	12	16	20	24	29	33	40	47	
Time	30 hours	48	60	72	72	72	96	96	120	120	

V LIMAX (Meisenheimer)

		Order of Quartet									
		I	II	III	IV	V	VI	VII	VIII	IX	X
Egg	Blastomere	n_1		$n_{1,1}$			$n_{1,1,1}$				
			n_2			$n_{2,1}$				$n_{1,2}$	
				n_3					$n_{2,1,1}$		
								$n_{2,1}$			
										$n_{2,2}$	
										(d)	
										(M)	
										+	
										(m)	
										(ent.)	(m ₁)
No. of Cells	4	8	12	16	20	24	28	32	36	45	51

These tables show, that in most cases the mesoderm formation arises in the stage of the tenth generation of ectomere-cells and at about the period when the cells number 50 or more without any regard to the duration of time consumed in their development. Further we learn that the genealogy of the ectomere-cells up to the stage of the sixth generation follows almost the same course, although the order of development sometimes varies with to species. And at the stage named, the differentiation of the germ-layers is first attained in some species. By referring to the table it is furthermore evident that the amount of deutoplasm present in the egg seems not to have any causal effect on the rate of differentiation. In this respect, *Neritina*, an egg rich in deutoplasm, forms the germ-layers in the same stage as *Limax*, and *Siphonaria*, which are scantily supplied with food-yolk.

Before closing I wish to express here my deepest obligations to Professors K. Mitsukuri and S. Watasé for their kind supervision of the present work.

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Explanation of Figures.

All the figures are drawn with a camera lucida, and are, unless otherwise designated, magnified with Zeiss D \times 4.

Reference letters used.

<i>a.</i>	anterior blastomere.	<i>M</i>	mesomere-cell.
<i>e.</i>	egg.	<i>p.</i>	posterior blastomere.
<i>lc.</i>	left bilateral cell.	<i>pb.</i>	polar body.
<i>m.</i>	mesomere-cell segmented.	<i>rc.</i>	right bilateral cell.

The arrow under the ectomere-cell indicates its course of cleavage and the Roman numeral shows the order of the quartet to be formed.

Figs. 1-36 illustrate the development of *Siphonaria*.

Figs. 37-60 illustrate that of *Aplysia*.

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ON THE FORMATION OF THE GERMINAL LAYERS IN GASTROPODA.

PLATE 1.

Plate I.

- Fig. 1. Egg mass of *Siphonaria* deposited on rock. Natural size. Arrow indicates the orientation of the animal during egg-deposition.
- Fig. 2. Three eggs magnified to show their manner of connection. Fresh. $A \times 2$.
- Fig. 3. Yolk spherules with vacuoles before disintegration. Fresh. $E \times 2$.
- Fig. 4. Egg after total disintegration of yolk spherules.
- Fig. 5. First cleavage stage, two blastomeres being connected only by a narrow bridge. Fresh.
- Fig. 6. Second cleavage stage. Its commencement, from above. Fresh.
- Fig. 7. Same stage, further advanced.
- Fig. 8. Completion of the same stage. Blastomeres are now designated as *A*, the left anterior, *B*, the right anterior, *C*, the right posterior, and *D*, the left posterior.
- Fig. 9. Cleavage of the first quartet of ectomere-cells. From apical pole.
- Fig. 10. Same stage. From posterior side.
- Fig. 11. Completion of the same stage, to show the position of cells. From apical pole.
- Fig. 12. Second ectomere-quartet stage, showing its formation. Apical view.
- Fig. 13. Same stage. Posterior view.
- Fig. 14. Commencement of third ectomere-quartet. Apical view.
- Fig. 15. Cleavage of fourth and fifth ectomere-quartets. Horizontal section.
- Fig. 16. Fifth ectomere-quartet stage with formation of entomere-cell *D*₁. Sagittal section.
- Fig. 17. Sixth ectomere-quartet stage. Horizontal section.
- Fig. 18. Formation of entomere-cell *D*₁. Horizontal section through vegetative pole.
- Fig. 19. Same stage. Sagittal section.
- Fig. 20. Cleavage of seventh ectomere-quartet. Horizontal section through vegetative pole.



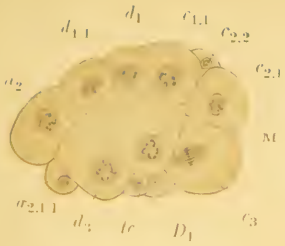
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PLATE II.

Plate II.

- Fig. 21. Formation of bilateral cells. Transverse section of a stage slightly more advanced than in Fig. 20.
- Fig. 22. Formation of eighth ectomere-quartet. Horizontal section through apical pole.
- Fig. 23. Same stage. Transverse section.
- Fig. 24. Stage before cleavage of mesomere-cell; constructed from sections so as to show the mutual relative position of cells. Cells forming the ventral side of the egg are colored blue.
- Fig. 25. Cleavage of mesomere-, and entomere-cells. Horizontal section through vegetative pole.
- Fig. 26. Cleavage of mesomere-cell M. Transverse section.
- Fig. 27. Completion of same stage, showing the relative position of ectomere-quartets. Horizontal section.
- Fig. 28. Formation of first mesoderm-cells. Sagittal section.
- Fig. 29. Same stage. Transverse section.
- Fig. 30. Stage after formation of tenth ectomere-quartet. Horizontal section near vegetative pole.
- Fig. 31. Horizontal section through vegetative pole, showing complete enclosure of mesomere-cells by epibolic growth of entoderm-cells.
- Fig. 32. Cleavage of second mesoderm-cells. Horizontal section.
- Fig. 33. Same stage. Sagittal section.
- Fig. 34. Formation of second entoderm-cells. Horizontal section.
- Fig. 35. Cleavage of third mesoderm-cells. Transverse section of the posterior side.
- Fig. 36. Formation of fourth mesoderm-cells. Sagittal section.
- Fig. 37. Eggs of *Aplysia*. Fresh.
- Fig. 38. Same, highly magnified. Fresh.
- Fig. 39. Commencement of first cleavage stage. Side view. Fresh.
- Fig. 40. Formation of blastomere-cells. Side view.
- Fig. 41. A slightly more advanced stage of Fig. 40. Apical view. Fresh.
- Fig. 42. Completion of same stage, showing the proper positions of blastomeres. Apical view. Fresh.



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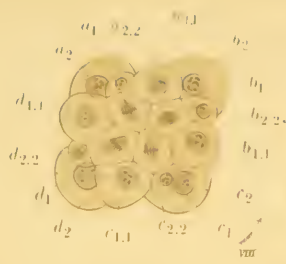


Fig. 22

Fig. 33

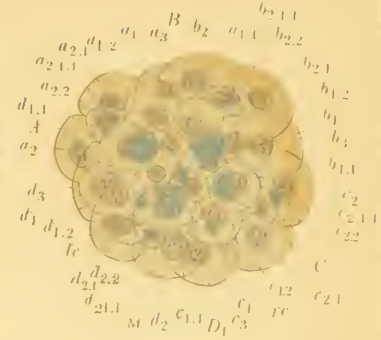


Fig. 24

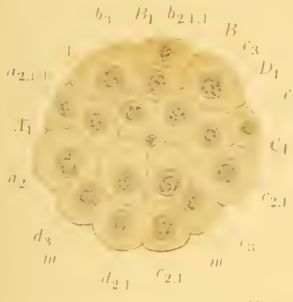


Fig. 27

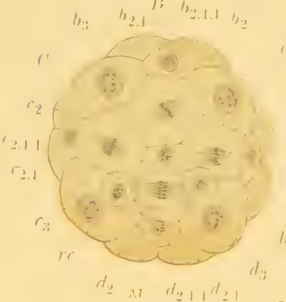


Fig. 25

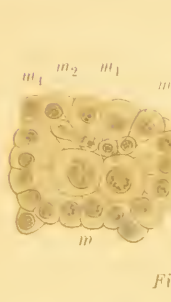


Fig. 35

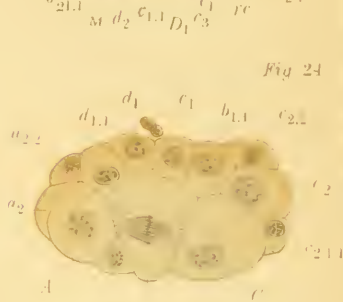


Fig. 26

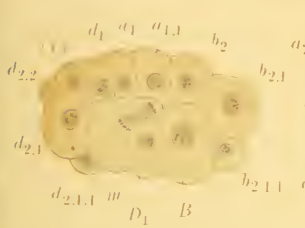


Fig. 28

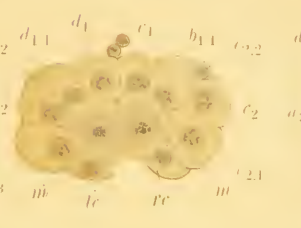


Fig. 29

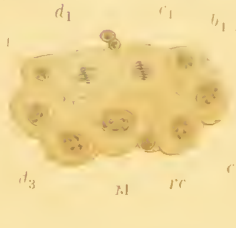


Fig. 24

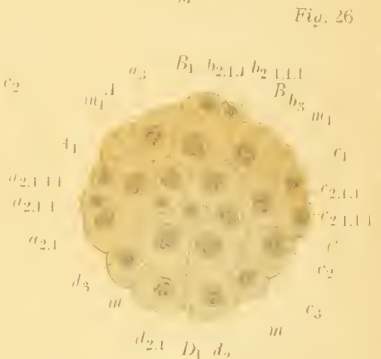


Fig. 30

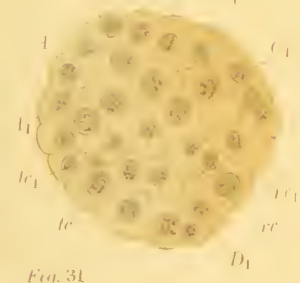


Fig. 31

Fig. 32

Fig. 34

Fig. 37



119. 10

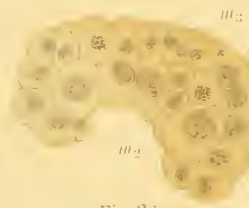


Fig. 36



Fig. 38

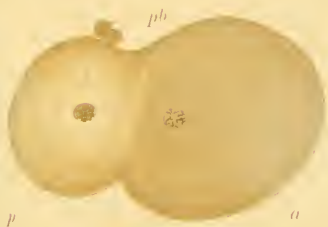


Fig. 39)

Fig. 41

Fig. 42

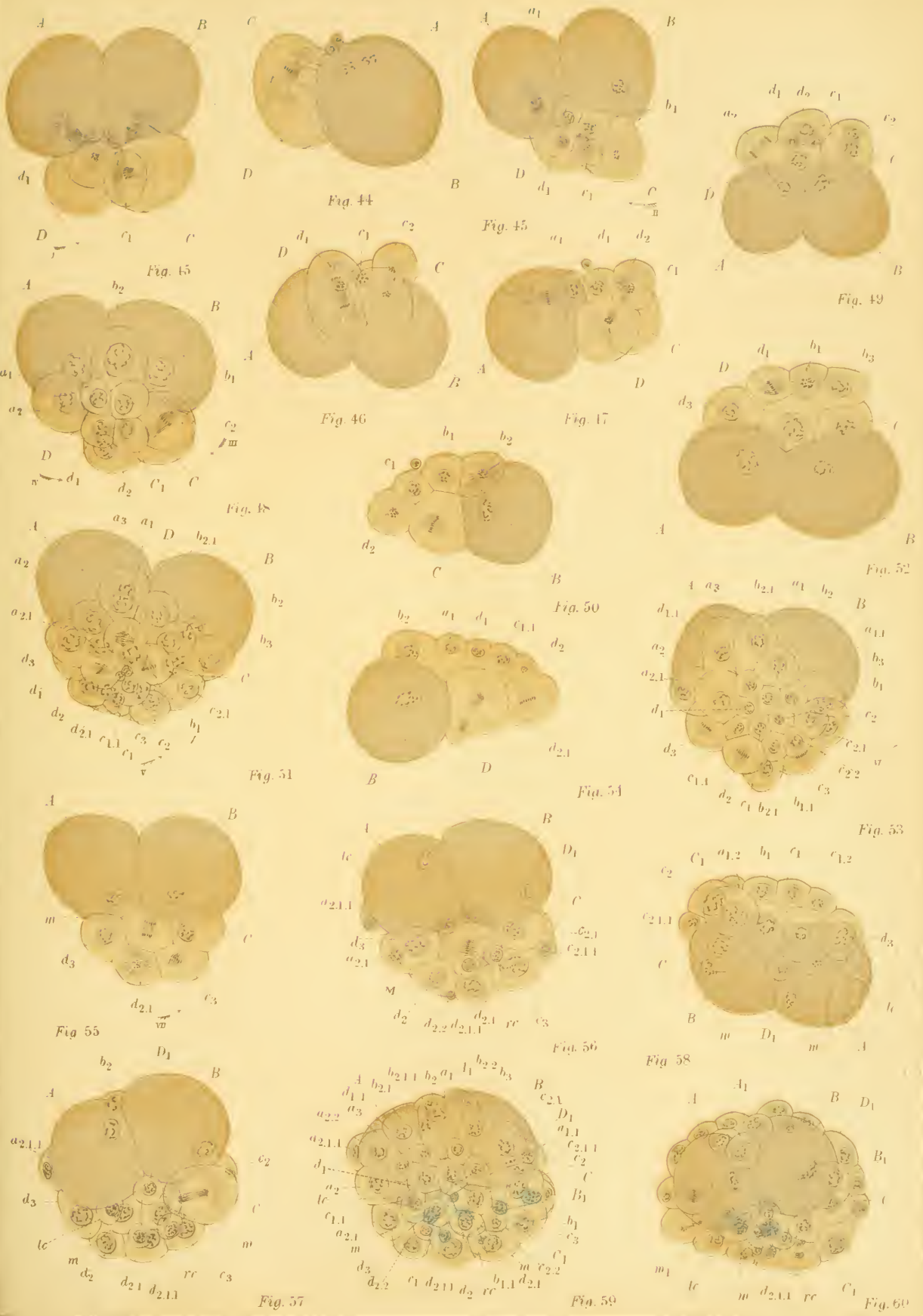
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PLATE III.

Plate III.

- Fig. 43. Formation of first ectomere-quartet. Apical view.
Fig. 44. Same stage. Right side view.
Fig. 45. Formation of second ectomere-quartet. Apical view.
Fig. 46. Same stage. Posterior view.
Fig. 47. Same stage. Left side view.
Fig. 48. Simultaneous formation of third and fourth ectomere-quartets stages. Apical view.
Fig. 49. Same stage. Posterior view.
Fig. 50. Same stage. Optical sagittal section.
Fig. 51. Formation of fifth ectomere-quartet stage. Apical view.
Fig. 52. Same stage. Optical transverse section.
Fig. 53. Cleavage of sixth ectomere-quartet, and formation of bilateral cells. Optical horizontal section.
Fig. 54. Same stage, with formation of seventh ectomere-quartet, and entomere-cell D_1 . Sagittal section.
Fig. 55. Same stage, with formation of bilateral cells. Horizontal section.
Fig. 56. Cleavage of mesomere-cell. Optical horizontal section.
Fig. 57. Formation of first entoderm-cells. Optical horizontal section.
Fig. 58. Completion of same stage. Optical transverse section.
Fig. 59. Stage before formation of mesoderm-cell m_1 showing the arrangement of cells. Cells on ventral side are colored blue.
Fig. 60. Formation of first mesoderm-cell stage. Optical horizontal section.



Cretaceous Cephalopoda from the Hokkaidō.

PART II.¹⁾

Turrilites, Helicoceras, Heteroceras, Nipponites,
Oleostephanus, Desmoceras, Hauericeras,
and an undetermined Genus.

By

Hisakatsu Yabe, *Rigakushi.*

University Hall, Imperial Univ. of Tōkyō.

With 6 plates

TURRILITES LAM.

D'ORBIGNY brought nearly all of the turreted forms of Ammonites under one of the three genera, *Turrilites*, *Helicoceras*, and *Heteroceras*, distinguishing at the same time two groups in the first genus, namely *Turrilites rotundati* and *T. angulati*.

1) Since the publication of the first part of this memoir, a number of valuable papers relating to foreign Cretaceous Cephalopod fauna have appeared both in Europe and America. First of all, mention must be made of the works of Dr. F. M. ANDERSON (Cretaceous Deposits of the Pacific Coast, 1902) and of Dr. J. F. WHITEAVES (On some Additional Fossils from the Vancouver Cretaceous, 1903), to both of whom we are indebted for much accurate and important knowledge concerning the Cretaceous deposits of the region along the Pacific coast of the United States and Canada. A comparison of the results of these papers with those reached by Professors YOKOYAMA and JIMBŌ and the present writer, will at once bring out some remarkable faunistic resemblances between the deposits of California and

Soon after D'ORBIGNY, QUENSTEDT¹⁾ considered the separation of *Helicoceras* from *Turrilites* quite unnecessary, while SHARPE²⁾ and STOLICZKA³⁾ were of opinion that the so-called group of *T. rotundati* should be brought under the genus *Helicoceras*, retaining the name *Turrilites* only for the *T. angulati* of D'ORBIGNY. PICTET,⁴⁾ however, proposed to divide *Helicoceras* into two groups, the one having a short spire and widely separated volutions and the other showing a high spire and less widely separated volutions. The first of these groups he called *Helicoceras* proper, while the second as well as the group, *T. rotundati*, were considered by him to be distinct genera.

MEEK⁵⁾ like D'ORBIGNY took *Helicoceras* in the most restricted sense and divided it into *Helicoceras* proper, *Patoceras*, and

Canada on the one side, and those of the Hokkaidō on the other. A discussion of these, however, the writer intends to put forth in the last part of this work.

As to the new fossil localities in the Hokkaidō, no important addition to our knowledge has been made during recent years; but several new forms have been brought back by geologists who have lately visited the localities already known. Among these, the writer would mention a valuable collection made by Prof. YOKOYAMA at Urakawa, a locality that had not been visited by geologists for more than twenty years.

During the last four years, the writer has devoted much time to the study of the morphology of the Hokkaidō Ammonites, and has also taken the opportunity of making himself acquainted with the development of several of their predominating types, for it has now become clear that a mere morphological study of adult specimens is not sufficient for the establishment of their real affinities, and that by the study of their development only can such knowledge attained. Consequently, the result obtained from this side of the study is also occasionally embodied in the following descriptions.

In this second part, the following genera are described:—

- 1) *Turrilites*, *Helicoceras*, *Heteroceras* and *Nipponites*.
- 2) *Oleostephanus*.
- 3) *Desmoceras* and *Haueriaceras*.

There is also one species whose generic position is still undetermined.

The order in which the different groups are here treated is not due to the presence of any mutual relations existing among them but merely for the sake of convenience and of avoiding too long a delay in the publication of the paper.

1) QUENSTEDT: Petrefaktenkunde Deutschlands. I. Cephalopoden. P. 297.

2) SHARPE: Mollusca of the Chalk. P. 59.

3) STOLICZKA: l.c. p. 183.

4) PICTET: Paléont. Suisse. Foss. de Ste. Croix. P. 120.

5) MEEK: Invert. Cret. and Tert. Foss. of the Upper Missouri County, p. 485.

Spiroceras. STOLICZKA¹⁾ said that "the position of the siphuncle and the symmetrical or unsymmetrical division of the sutures ought to be regarded as a much better distinguishing character than the kind of volutions," while MEEK²⁾ argued, "it seems not justified to unite typical *Helicoceras* characterized by very slender, widely separated volutions, forming so broad a curve as to give origin to a very wide umbilical cavity and *Turrilites rotundati*, generally provided with much rounded, contiguous whorls."

ZITTEL,³⁾ in his Handbuch, accepted four subgenera of *Turrilites*, namely *Turrilites* s. str., *Lindgia* (? *Helicancylus*), *Heteroceras*, and *Helicoceras*.

Remarkably different from the views above alluded to, are those held by NEUMAYR and HYATT. NEUMAYR⁴⁾ believed that *Helicoceras* together with *Toxoceras*, *Anisoceras*, *Ptychoceras* and others should be brought under the genus *Hamites* (in the wide sense), while he placed *Heteroceras* near to *Crioceras*, a genus which according to him is tolerably distinct from *Turrilites* and *Hamites*.

According to a later publication of HYATT,⁵⁾ these secondary forms have no affinity with *Lytoceras* and its allies, and consequently are brought by him under Acanthoceratida and Cosmocerotida. The genera which are treated as Acanthoceratids are *Helicoceras*, *Heteroceras*, and *Lindgia*, which form his family of Hamitidae. Of those placed under Cosmocerotida, *Bostrycoceras* HYATT is treated under Nostoceratidae, *Helicancylus* under Ancyloceratidae, *Turrilites* and *Ostlingoceras* HYATT under Turrilitidae, and *Hyphantoceras* HYATT under Anisoceratidae.

1) STOLICZKA: l.c. p. 183.

2) MEEK: l.c. p. 487.

3) ZITTEL: Handbuch der Palaeontologie, I, 2. p. 445.

4) NEUMAYR: Die Ammoniten der Kreide u. Systematik d. Ammonitiden, pp. 894, 938.

5) HYATT: Cephalopoda in ZITTEL's Text Book of Palaeontology, translated by EASTMAN.

In the study of the Cretaceous Cephalopoda, one of the most difficult tasks is to define the exact limits of the different genera established on the turreted forms of Ammonites. HYATT's classification by creation of many new genera may possibly be an improvement to the previously existing ones but it cannot be followed here, for the generic diagnoses and discussions on the taxonomy are not yet published. Therefore, the present writer is obliged to follow the old and well known classification of D'ORBIGNY as modified by SHARPE and STOLICZKA though it is apparently unnatural. Yet, it is quite necessary to create a new genus, as there is one specimen which entirely differs from the known types in the development of its shell.

The group *Turrilites*, in its most comprehensive sense, forms a rather inconspicuous element in our fauna. Notwithstanding their display of various modifications in the upper Ammonite-beds, specimens are rare in all the localities, so that the description of several species of them must be left imperfect. Besides those from the upper Ammonite-beds, two species of the Cenomanian types are also described below. These the writer considers as specially important, for the fauna of the lower horizons is very poor.

TURRILITES cfr. **BERGERI** BRONGNIART.

Pl. III., fig. 1.

1902. *Turrilites* cfr. *Mantelli* YABE: List Cret. Amm. Hokkaidō in the Outline of the Geology of Japan. 2nd Edition. 1902.

Compare :

1840. *T. Bergeri* D'ORBIGNY : Pal. Fr. Terr. Crét. Tome I.,
p. 590, pl. CXLIII., figs. 3-6.
1847. *T. Bergeri* PICTET et ROUX : Moll. des Grès Verts.,
p. 148, pl. XV., fig. 8.
1847. „ „ QUENSTEDT : Petref. Deutsch., I., p. 300,
pl. XXI., fig. 26.
1856. „ „ SHARPE : Moll. of the Chalk, p. 65, pl.
XXVI., figs. 9-11.
1861. „ „ PICTET et CAMPICHE : Sainte-Croix. T. II.,
p. 134, pl. LVIII., fig. 1-5.
1866. „ „ STOLICZKA : Cret. Ceph. South India. p.
185, pl. LXXXVI., figs. 3-6.
1897. „ „ KOSSMAT : Südindische Kreidef. p. 45.
1903. „ „ CHOFFAT : Le Crét. de Conducia, p. 15, pl.
I., figs. 3-5.

Shell turreted, sinistral, with an apical angle of about 10° . Whorls contiguous, slowly increasing in size; rounded externally, and slightly concave on the upper side. Umbilicus very narrow. External surface furnished with four rows of numerous short and laterally compressed spines, the upper two of which are a little closer together than the others. Also the number and size of spines in the two upper rows (about 32 on the last volution) are different from those in the lower ones, those of the latter being very slightly larger in size and fewer in number. The uppermost row of spines is concealed under the succeeding whorl. There are also feeble traces of ribs on the upper and lower surfaces of the whorl. The number of these equals that of the spines on it.

The septum has not been seen.

Only a single fragment of this shell having been found, it is hardly possible to get a general idea of its shape and sculpture. The writer has long been under the impression that it resembles more or less clearly *T. Mantelli* SHARPE, but the slender, elongate outline of the shell and the four rows of spines on the whorls being not much different in size and number, seem to show that it is more closely related to *T. Bergeri* BRONGNIART. Among the figures of the said species from foreign Cretaceous deposits, which are accessible to the writer, that of a fragment with two contiguous whorls from the Chloritic Marl of Bonchurch, Isle of Wight (shown by SHARPE in his Pl. XXVII., fig. 10) exhibits the closest resemblances.

STOLICZKA describes the tubercles of *T. Bergeri* as often spinose and sharp, but none of his figures shows tubercles so sharp, and laterally so compressed as in our specimen which in this respect comes closer to an immature one figured by SHARPE in his monograph (Pl. XXVI., fig. 11).

In point of the existence of only a slight difference in the size and number of spines in the upper and the lower rows, this species resembles *T. Mantelli* more than *T. Bergeri*, while the close arrangement of the spines in each row makes it resemble *T. Bergeri* var. *miliaris* (PICTET et CAMPICHE: l. c. fig. 5).

Taking these several points into consideration, it appears to be quite evident that this form is specifically distinct, not only from *T. Bergeri* and *T. Mantelli*, but also from all others hitherto described, the nearest ally however being *T. Bergeri*.

Locality —The Popet, near the mouth of the Sanushibe.

Horizon :—Lower Ammonite-beds.

Foreign localities and horizons of *T. Bergeri* and *T. Mantelli* :

—*T. Bergeri* BRONGNIART occurs in the deposits of the Albian, Vraconian and Cenomanian ages of England (Chalk with green grains at Chardstock), France (Cenomanian of Bayet, Auxon; Albian of Aigulun and Savoy), Austria, Switzerland and Italy. This species has also been found in Algeria associated with *Turritiles costatus* and *Acanthoceras rotomagensis*, and in Conducia together with *Belemnites minimus* LISTER, *Phylloceras* cfr. *semi-striatum* D'ORB. and *Acanthoceras laticlavium* var. *moçambiquensis* CHOFFAT. STOLICZKA calls it a common fossil of the Utatur group of Odium and Moravatur, South India.

T. Mantelli has been met with in the Gray Chalk of Sussex and the Tourtia of Essen.

TURRILITES KOMOTAI M.

Pls. I. and II.

Dimensions :—

Height of the spire.	18.0 cm.
Diameter of the last volution.	18.0 „
Width of the umbilicus.	6.0 „
Height of the last whorl.	6.3 „
Breadth of the last whorl.	7.0 „

Shell sinistral, composed of numerous contiguous whorls,¹⁾ rapidly increasing in size, with an apical angle of about 70°. Whorls rounded externally, slightly convex on the upper and concave on the lower surface. Section of the whorl nearly elliptical, somewhat broader than high; rather trapezoidal in the last volution. Suture of the spire deep. Umbilicus moderately

1) Only four volutions are present in the specimen, three or four others near the apex having been broken off.

wide, being about one third the diameter of the last volution. Surface with ribs and spines, the former arranged in two series and the latter in four rows. The ribs on the upper part of the whorl are numerous and flat, separated by wide intervals; they are oblique, bending strongly forward, distinct near the external side, but gradually becoming feeble toward the umbilicus. Each of these ribs bears three short spines, close to the external side; they are moderately sharp and compressed in the spiral direction. The external surface of the whorl shows a second series of ribs which are much broader than those of the first series and about a half their number. The ribs of this series are also slightly oblique and somewhat concave in front, with flat intervals of almost the same width as the ribs themselves. The middle portion of each of these ribs on the body whorl carries a long spine. The spines are more or less trigonal in a transverse section, rounded behind, and flattened in front. Their surface is ornamented with fine lines of growth, in addition to a delicate median line on the flat side. Most of the spines on the other whorls have been cast off, and the remaining basal portions which look like tubercles are usually covered with a thin calcareous layer. The umbilical side of the whorl is smooth while the basal surface shows the impression corresponding to the surface marking of the upper side of the foregoing volution.

The specimen is unfortunately not in a condition to show the position of the siphuncle, nor all the ramifications of the lobes and saddles which are only partly though distinctly seen on the whorl near the apex.

T. Komotai is related to *T. Cunliffianus* STOL.¹⁾ from the Utatur Group of Odium, South India, although the distinction

1) STOLICZKA: Cret. S. India, p. 190, pl. LXXXIX.

is quite obvious. In the Indian species, the number of ribs on the upper side of the whorl is nearly equal to that of the ribs on the lateral side, or to that of the tubercles arranged in two rows between the upper and lower series of ribs, but more numerous than that of the tubercles in the lowest row.

Locality and horizon:—This majestic form of *Turrilites* is at present represented only by a single specimen which has been found by Mr. Komota in a marly nodule found below a cliff of the Ikushumbetsu directly above the coal mine.

The matrix of this specimen is a sandy marl, dark grey in color, and compact in texture, agreeing in every respect with that of the nodules in the sandstone of the cliff above cited. Therefore there is no doubt that the specimen came from that locality, as is also shown by the presence of an impression of *Margarita funiculata* YOKOYAMA on the matrix of this specimen, a Gastropoda very common in the above sandstone. This sandstone cliff is the chief locality of the typical fossils of the lower *Acanthoceras*-zone.

The writer has much pleasure in associating with this species the name of its collector Mr. KOMOTA who was kind enough to present it to the museum of the Geological Department of the Tōkyō University.

HELIOCERAS SCALARE M.

Pl. III., figs. 2 and 3.

Shell helicoid, forming a widely open coil; either sinistral or dextral. Whorls circular or subcircular in section, gradually enlarging anteriorly. Surface with numerous transverse ribs,

separated from one another by a tolerably broad and flat interval. Ribs sharp, always simple and smooth, becoming somewhat feebler and more flexuous on the umbilical side.

The suture line has been only partly examined. It shows a single lateral saddle and lobe, both of which are twice deeply bifid and finely incised. The siphonal saddle is slightly higher than the lateral one.

One of the specimens (fig. 2.) is from the *Scaphites*-beds of the Opiraushibets. It is nearly a volution of a sinistral shell, less than 4 mm. in diameter at the smaller end, and about 8 mm. at the other end. One half of this whorl is furnished with 45 ribs of which 8 are broader and more elevated than the others, especially on the outer side. The smaller ribs which are found between these larger ones number 4 to 10. All the ribs are arranged transversely, except near the larger end of the whorl where they are a little oblique.

The second specimen is from the Yūbarigawa. It is a volution of a dextral shell, a little larger than the one mentioned above. As in *Heteroceras Otsukai*,¹⁾ the siphon bends downward from the median line at a certain point of the external side of the whorl.

Another example drawn in fig. 3, pl. III., is a small fragment of a larger, dextral shell. These figures show in sufficient clearness the mode of arrangement of the ribs on the whorl.

Localities :—The middle course of the Opiraushibets, and the Yūbarigawa. Four specimens from the former locality and the two from the latter have been examined.

Horizon :—*Scaphites*-beds.

1) Vide p. 15.

HELIOCERAS (?) VENUSTUM M.

Pl. III., fig. 4; pl. V., figs. 1 and 2.

1902. *Hamiles venustus* YABE: the List of Ammonites from the Cretaceous of the Hokkaidō, in Outlines of the Geology of Japan: Descriptive Text to accompany the Geological Map of the Empire.

Shell sinistral, forming a helicoid spiral of a very wide coil. Whorls slender, very slowly increasing in diameter toward the anterior end; subcircular in cross-section when young, transversely oblong in the aged specimens. Surface with numerous transverse striae and periodic ribs, the latter hardly distinguishable from the former on the umbilical side, but becoming gradually higher toward the external side, until they are most elevated on the upper side, each being here furnished with two tubercles. Intercalated striae numerous, simple, smooth and uniform, becoming somewhat feebler on the umbilical surface; their intervals vary from 1.0 mm. to 0.5 mm. Both striae and periodic ribs maintain a slightly oblique course.

The suture line is only partly visible. It is apparently very similar to that of the preceding species, being divided into three bifid saddles and a corresponding number of similarly bifid lobes on either side of the siphonal line. These saddles and lobes are nearly uniform in size and are moderately incised. The external lobe is somewhat shallower than the others. The siphon is on the median line of the external surface of the whorl.

There are two specimens of this pretty species in the writer's collection, one of which is from lower part of the *Pachydiscus*-beds, exposed along a right tributary of the Saushi-sanushibe.

It is a young volution with the umbilicus 5.5 cm. wide and the larger end 1.3 cm. broad. The other one which is from the *Scaphites*-beds of the Opiraushibets, is a fragment of the septate portion of a larger shell.

The present species is evidently related to *Heteroceras ceratopse* ANDERSON¹⁾ from the Smith ranch, east of Phenix, Oregon, for they have many points of resemblance in the general form and size of the shell and also in the character of the ribs. Indeed, the resemblance is so close that their separation into two distinct species may be doubted. But according to the description of ANDERSON, the American form possesses periodic ribs whose highest elevation is on the siphonal line and is not so elevated on the upper side as in the Japanese specimens. Although the difference seems to be trifling, yet the writer considers it prudent at present to regard them as two distinct species.

The discovery of more materials from both sides of the Pacific will doubtless throw light on this question.

Localities and horizons:—The lower horizon of the *Pachydiscus*-beds of the Sausshi-sanushibe, Iburi Prov., and the *Scaphites*-beds of the Opiraushibets, Teshio Prov. One specimen from each locality.

HETEROCERAS (?) ŌSHIMAI M.

Pl. III., figs. 5 and 6.

Shell turreted, sinistral; volutions free, especially near the anterior end. Whorls growing slowly; obliquely elliptical in section; the surface carrying both ribs and tubercles. Ribs

1) ANDERSON: Cretaceous Deposits of the Pacific Coast. Proc. Calif. Acad. Sci. 3rd Series, Vol. II., no. 1, p. 91, pl. III., figs. 100-101.

numerous, the last volution having 45, separated by intervals wider than their breadth. Ribs uniform in size except on the upper border of the whorl, where the tuberculated ones become thicker, while the smooth ones become more faint; arranged obliquely, curving backward on the lower border and forward on the upper. Some of the ribs bear four tubercles or more correctly rounded spines which form four horizontal rows, two on the upper border, one in the middle of the external side and another on the lower border, and these tuberculated ribs alternate with 1-4 smooth ones. Tubercles subequal in size. Internal side of the whorl nearly smooth.

Of this species there is a non-septete fragment of moderately large size composed of two circuits, of which the posterior circuit and one half of the other are very close together although not quite in contact, while the remaining half is detached from the other part. The specimen is represented in pl. III., fig. 5.

The second example, which probably belongs to the same species, is a young shell, very loosely twisted and ornamented with distinct, narrow, oblique ribs alternately bearing two short spines on the upper border (fig. 6).

I have not yet seen the suture line of this species, but the other characters are enough to distinguish it from any known species of *Turritiles*. The nearest approach to the Japanese form is made by *T. Reussianus* D'ORBIGNY, from which it differs in having very oblique, flexuous and subequal ribs. Still their resemblance is so great that they must be considered as closely allied forms.

T. Reussianus is placed by SCHLÜTER¹⁾ under the genus

1) C. SCHLÜTER: Cephalopoden d. oberen deutsch. Kreide. 1871. P. 109, pl. XXXII., figs. 13-21; pl. XXXIII., fig. 1.—A. FRITSCH u. U. SCHLÖNBACH: Ceph. d. böhm. Kreidef.

Heteroceras, while FRITSCH and others bring it under *Helicoceras*. Recently, however, HYATT¹⁾ raised it to the type of his genus *Hyphantoceras*.

T. Reussianus occurs in the *Reussianus*-zone of England and Northwestern Germany, in the zone of *Epiaster brevis* of France, in the Pläner Kalk of Saxony and the Priesen beds of Bohemia.

The species is named in honour of Dr. R. ŌSHIMA of the Hokkaidō Colliery Railway Company in recognition of his courtesy offered to the writer and his kind interest taken in this palaeontological study.

Localities :—The larger specimen was obtained in situ near the confluence of the Yoshiashizawa with the Ikushumbets, and the smaller one in the upper course of the Shi-kuruki, a tributary of the Yūbarigawa.

Horizon :—*Scaphites*-beds.

HETEROCERAS (?) ŌTSUKAI M.

Pl. IV., figs. 1-2., pl. VI., fig. 7.

1894. *Turritiles* sp. JIMBŌ : Beiträge z. Kennt. d. Fauna d. Kreidef. Hokkaidō, p. 41, pl. I. (XVII.), figs. 8, 8a.

Shell turreted, volutions free, sometimes sinistral and sometimes dextral ; the anterior ones making occasionally a narrower

P. 47, pl. XIII., fig. 16? ; pl. XIV., figs. 14-19 (? 14-18) ; pl. XVI., fig. 9?—A. FRITSCH : Studien im Gebiete der böhm. Kreidef. IV. Die Iberschichten, p. 92, fig. 44. V. Priesener Schichten, p. 79, fig. 62.—H. WOOD : The Mollusca of the Chalk Rock. Pt. 1. Quart. Jour. Geol. Soc. London. Vol. LII. 1896. P. 74, pl. II., figs. 3-5.

1) HYATT : Cephalopoda in ZITTEL'S Text Book of Palaeontology, translated by EASTMAN. 1899. P. 578.

coil than the posterior, at times a wider one. Umbilicus as wide as the breadth of the whorl. Whorls slowly increasing in diameter with growth, nearly round or somewhat transversely oblong in section and ornamented with numerous ribs (about 50 on a volution). Ribs uniform, smooth, usually simple, rarely bifid; arranged slightly obliquely; moderately sharp but broad at the base on the external side, thence becoming gradually narrower toward the upper border and suddenly toward the lower border, while they are fine, though still distinct, on the umbilical side. Interspaces between the ribs flat or slightly concave, being twice as broad as the ribs.

Suture line partly known. External lobe shallow, with a high broad siphonal saddle; first lateral lobe very broad, regularly bifurcating twice; external saddle symmetrically bipartite, inclining inward; first lateral saddle broad and also bifid. All the lobes and saddles are finely serrated.

Of the three examples of this species hitherto found, one (pl. IV., fig. 2.) is a partly septate fragment composed of $1\frac{1}{2}$ volutions, measuring 2.5 cm. in diameter at the smaller end. Where the shell is not preserved the ribs appear broad and round, separated by very shallow furrows. The suture line and the siphuncle are also seen in the part above alluded to. The siphuncle is abnormal, being pushed down anteriorly from the normal median position on the external side of the whorl. A quite similar case has already been noticed by F. B. MEEK on a shell of *Heteroceras tortum* MEEK and HAYDEN.¹⁾

The second specimen (pl. IV., fig. 1.) is a somewhat smaller one, composed also of $1\frac{1}{2}$ volutions.

1) MEEK: Invert. Cret. and Tert. Foss. Upp. Missouri County. Rep. U. S. Geol. Surv. of the Territories. Vol. IX., 1876, P. 481, pl. XXII., figs. 4a, b, c.

Turrilites sp. of JIMBŌ is a small specimen, of ill preservation, but its form and surface markings are so like the two individuals above described that it may safely be regarded as belonging to the same species.

Compare *Heteroceras elongatum* WHITEAVES¹⁾ from the Nanaimo group of Vancouver. Though decidedly distinct, the two show certain similarities in their characters.

The writer takes this opportunity of associating with this species the name of Mr. ŌTSUKA of the Imperial Geological Survey, who once undertook a geological trip in the Mesozoic district along the upper course of the Yūbarigawa.

Localities and horizon:—The first specimen was picked up in the river bed of the Yūbarigawa above the confluence of its right branch, the Wenhorokabets, with it, while the second is from the *Pachydiscus*-beds of the Kikumezawa, a tributary of the Ikushumbets. JIMBŌ's specimen is labelled "Ponnaibuts, a place close to the town of Urakawa, Hidaka Prov."

VAR. **MULTICOSTATA** M.

Pl. III., fig. 9; pl. IV., fig. 3; pl. VI., fig. 8.

Under this head, the writer brings four fragments of turreted shells which in their general habit agree fairly well with the typical species, but differ in having more open coils, slender whorls, and narrower and more numerous ribs. Consequently, the ribs of these shells are set more closely and also more obliquely than in the typical species.

1) WHITEAVES: Mesozoic Fossils. Pt. 2, p. 100, pl. XII. Pt. 5, p. 331, pl. XLIV., fig. 2.

All these distinguishing characters, however, vary much among the specimens. One of these specimens approaching the typical species in the surface marking possesses, at the same time, whorls not so widely open as in the others, thus undoubtedly forming a connective link between the typical species and the above mentioned type of the variety. A specimen representing the opposite extremity of variation shows a suture line which does not essentially differ from that of the typical species (fig. 8). There is another specimen from the Shisanushibe which the writer with some hesitation refers to the same variety.

Localities:—The four specimens above mentioned are from (1) the Opiraushibets where it was found as a pebble close to the confluence of the Panke-kenebets (fig. 3), (2) the Opiraushibets in its middle course, (3) the Shisanushibe, a tributary of the Popet, and (4) the Yūbarigawa (fig. 9). The specimen from the last locality was found in the collection of JIMBŌ.

Horizon:—All the specimens being obtained from among the river gravels, the exact geological horizon in which they occur is of course unknown. But the one from the middle course of the Opiraushibets was found associated with *Scaphites puerulus* JIMBŌ in a marly nodule; hence, there is a great probability, that it was derived from the extensive *Scaphites*-beds in the neighborhood of the above river.

HETEROCERAS (?) JAPONICUM M.

Pl. III., fig. 8.

1902. *Turrilites* cfr. *indicus* YABE: List of Ammonites from the Cretaceous of the Hokkaidō, in Outlines of the

Geology of Japan : Descriptive Text accompanying the
Geological Map of the Empire.

The writer proposes the following diagnosis by examining a specimen with two volutions of the anterior portion of the shell preserved.

Shell dextral, narrowly elongated; volutions widely apart longitudinally; umbilicus moderate in width. Whorls somewhat obliquely elongated in cross-section. Surface ornamented with numerous ribs and also some periodic ones. Ribs strong, simple, smooth and uniform, transverse and nearly straight on the external surface of the whorls, curving gently on the inner upper margin and thinning gradually inside; intervals wide (about 2 mm. on the average), smooth and flat. Periodic ribs very remote from one another, one on two volutions, somewhat broader and much higher than the other ribs. Septation unknown.

It is by no means certain that the present species is specifically distinct from *T. indicus* STOLICZKA¹⁾. The Indian species is provided with volutions, contiguous when young and detached in the advanced stage of growth with the ribs also nearly similar in characters, the only difference being in that the deeper periodic furrows are bounded behind by a strong rib. According to KOSSMAT,²⁾ *Heteroceras indicum* is a species resembling *H. polyplocum* ROEMER but distinguished by its constantly smaller size and total absence of tubercles which often appear on the surface of the whorl of *H. polyplocum*.

F. M. ANDERSON³⁾ referred a small form from Oregon, coiled in a flat spiral, to *H. indicum* with query. The whorl of the

1) STOLICZKA: Cret. S. Ind., p. 184, pl. LXXXVI., figs. 1-2. KOSSMAT: Untsuch. ü. d. südind. Kreidef., p. 143, pl. XX., figs. 5 and 6.

2) KOSSMAT: l. c. p. 143.

3) ANDERSON: Cretaceous Deposits of the Pacific Coast. 1902. P. 91, pl. III., figs. 96-97.

American specimen is described as showing three or four constrictions, besides the numerous ribs of the ordinary kind.

Besides the specimen on which the above description is based, there is another from the Opiraushibets which is much more fragmentary, and which therefore the writer refers with much hesitation to the same species.

Localities :—The Yubarigawa, Ishikari Prov. (figured), and the Opiraushibets, Teshio Prov.

Horizon :—Upper Ammonite-beds.

Localities and horizons of the allied species :—

H. indicum STOL. The uppermost bed of the Trichinopoly group of South India.

H. indicum STOL. (?). The lower Chico group of Smith ranch near Phoenix, Oregon.

HETEROCERAS (?) ORIENTALE M.

Pl. III., fig. 7.

There are two internal casts of a shell which the writer takes for a new species. The larger and better of these two specimens, has only one and a half volutions preserved. The diagnosis runs as follows :—

Shell sinistral, very much elongated longitudinally. Volutions slender, increasing in size gradually toward the anterior portion, making very oblique and open coils. Whorls oblong in cross-section with the longer axis oblique to the axis of volution. Surface marked with very flexuous, transverse ribs except on the smooth inner side. Ribs slightly irregular in size, usually simple

and strong but not seldom bifurcating and then weaker; they make a backward curve on the lower margin and another forward one near the upper, where sooner or later they disappear. Intervals also not quite uniform, the breadth varying from 2 mm. to 3 mm. Tubercles rather prominent, arranged in four rows of which three are on the external side and one on the lower margin. All the rows are equidistant from one another and parallel to the suture except on the last portion of the shell in which they are more or less oblique to the latter. Ribs, except weak and short ones, bear a set of tubercles.

Although this species agrees with *T. cfr. Bergeri*¹⁾ in having four rows of tubercles and transverse ribs, yet there seems to be no further resemblance between the two. *Helicoceras hystriulum* WHITE²⁾ from the Cretaceous of Sergipe, South America, represents a species probably belonging to the same type as ours. Excepting this *H. hystriulum*, the writer is at present unacquainted with any form which makes even a distant approach to the Japanese shell.

Localities :—The Ikushumbets, Ishikari Prov., the exact position of the bed from which the specimens were derived is unknown. But the other Molluscan remains found together in the same marly nodule belong to the species common in the *Pachydiscus*-beds.

NIPPONITES MIRABILIS GEN. ET SP. NOV.

Pl. IV., figs. 4-7; pl. VI., fig. 6.

We have only a single specimen belonging to this entirely new and extraordinary type of Ammonites.

1) Vide supra.

2) WHITE: Contributions to the Paleontology of Brazil. 1888. P. 229, pl. XXII., figs. 3, 4.

At first the shell forms a more or less flat spiral coil wound sinistrally as in *Helicoceras*, its diameter being about 2.7 cm. and the cross-section of the whorl at the end of the second volution about 0.9 cm. The further growth is no longer spiral, but it consists in turning to the right and then to the left several times and thus forming many U-shaped curves which cover the first part of the shell from six directions, so that the plane of the curves roughly corresponds to the six sides of a cube. The limbs of each single curve and of those adjacent come nearly in contact.

In cross-section, the whorls of the younger, spiral portion are nearly round, while those of the older are somewhat oblong, the dorso-ventral diameter being a little narrower than the lateral one. The body chamber is probably long, as about two anterior curves seem not to be septated.

As our shell consists of several U-shaped curves, when it is compared with the ordinary *Turritiles*, one limb of a curve corresponds to a whorl of a sinistrally wound *Turritiles*, and the other to that of a dextrally wound one.

The ribs are simple, smooth and uniform (except at the anterior end), sharp and high on the external surface, becoming somewhat weaker inside; they are closely and obliquely set, separated by flat intervals of a moderate width. Only near the anterior end of the shell, the ribs become dissimilar, some of them being higher and broader than others, which proves the growth at these points had been frequently checked. With the exception of the anterior portion, the surface sculpture of this species is so much like that of *H. Otsukai* as to suggest the existence of a relationship between the two species. In the spirally coiled, posterior portion of this shell, the siphuncle is

sutural by which fact it is distinguished from *Helicoceras*. On the portion of the irregular growth, however, the siphuncle is always (?) situated in the median line of the external side.

The suture line was partly examined on the whorl which succeeds the regular spiral growth. It shows two saddles and corresponding lobes on one side of the siphonal line, and does not essentially differ from that of *H. Ōtsukai*. The two saddles are comparatively slender and nearly equal in height; both are bipartite with bifid subdivisions. The lateral lobe is very broad and bipartite, slightly exceeding the ventral one in depth. The siphonal saddle is relatively broad and high, with a few serrations along the margin.

The complicated mode of coiling the whorls in this species is better seen in the accompanying figures. In Plate IV., figs. 4 and 5 show its external aspect seen from two different directions, each U-shaped curve is marked with the Roman numerals II.—VI. and I'. II'. in the order of their succession. The first curve (I.), immediately succeeding the spiral portion, is not to be seen in these figures; the second curve which is only partly visible is marked II. and the third III. and so on. The seventh curve, being nearly upon the first one, is marked I'. and the eighth, for the same reason, II'.

Fig. 6 shows a longitudinal section of the specimen, the cross-sections of the whorls being hatched. The two volutions of the spiral portion appear as four round sections marked with Arabian numerals 1-4. The position of the siphuncle is also indicated on the sections by S.

Fig. 7 was drawn after a wire model showing the mode of coiling the whorls from the beginning to the end. Roman numerals are here also used in the same sense as before.

We do not know any morphological equivalents of this peculiar shell among similar tube-forming animals of the past or the present. The following cases of abnormal growth of the shell of *Turritites* and its allied genera may be taken into consideration.

(1.) The Ammonites with a conically spiral shell usually follow a certain law in their growth, having volutions which are either mutually in contact or separate; but cases often occur in which they show a portion near the mouth more or less perceptibly deflected in position from the preceding volutions. This change may be produced by the animal either pathologically or as the result of old age. We also learn from various sources, the occurrence of many examples in discoidal species, showing a slight tendency to become conically spiral in the anterior portion. QUENSTEDT and some others early called attention to this fact and seem to have believed the probable derivation of secondary forms from ancestral individuals of pathologic growth.

(2.) In some of the secondary forms, it is known that at the very beginning of development they show a normal growth, that is to say, a discoidal shell with volutions more or less involute. A remarkable case has recently been described by WHITEFIELD¹⁾ in *Heteroceras simplicostatum* from the Fort Benton group of the Black Hills. According to this author, the species has its younger portion composed of two straight limbs, close together, like *Hamites*. This seems to indicate the derivation of a more abnormal type from a less abnormal one.

(3.) Besides, there are a few cases in which the shell is coiled in a conical spiral, first to the right and then to the left,

1) WHITEFIELD: Observations on and emended Descriptions of *Heteroceras simplicostatum* WHITEFIELD. (By review.)

the latter portion surrounding the earlier one. Such double coils of a tubular shell around the same axis of volution, but in opposite directions, may be either accidental, or due to the animal itself having an inherent power of producing such coils.

(4.) Again, there are some species of the later Cretaceous which are remarkable in exhibiting a great range of individual variations on the mode of coiling the shell. The variations, however, are due to a loss of power in the animal, which as it grows no longer maintains its normal mode of coiling.

In the present species, in spite of its being represented by a single specimen, the mode of coiling the whorls can neither be accidental nor due to a loss of power to produce the regularly wounded shell, as it is too regular to admit any such supposition. That it is a *Turritites* or some allied genus which has modified its mode of growth on account of its advanced age is also inconceivable. Therefore, this formation of several U-shaped curves must be ascribed to the inherent power of the animal. It is for these reasons that the writer proposes to give a new generic name to this single specimen.

As above mentioned, this species has both suture and sculpture which indicate its derivation from some species of *Heteroceras* (?), e.g., *Heteroceras* (?) *Ōtsukai* in turreted groups of Ammonites. From the form of the shell, we can readily see that the animal led neither a free swimming life nor a sessile one, but was a creeper on the sea-bottom as is the generally accepted view of *Turritites*.

QUENSTEDT after describing *Turritites reflexus*—an extraordinary form of a doubly coiled shell, says:¹⁾

“Es mag wahrscheinlich Formen gehen, wo sich dieses hin-

1) QUENSTEDT: *l.c.* p. 306.

und herdrehen noch zum öftern wiederholt, sie sind den Weber-spulen zu vergleichen, über welche die Faden sich hin und her über einander windet. Was setzt das nicht für eine Beweglichkeit der Organe voraus!"

Of course, QUENSTEDT did not know, then, that such a peculiar form as the present species would occur in Japan.

INCERTÆ SEDIS.

There are few forms of Ammonites in our fauna, more interesting than the single specimen described below under the name of *Ammonites Kotoi*. Its characters agree in several respects with *Olcostephanus superstes* KOSSMAT¹⁾ which that author, together with *Ammonites rudra* STOLICZKA,²⁾ temporally brought under the genus *Olcostephanus*. He, of course, acknowledged the phyletical relation of these two Ammonites to *Vascoceras* on one side and to *Acanthoceras* on the other, although they much resemble, not only in the general aspect of their external form, but also in their suture line, the lower Cretaceous and the Jurassic species of the genera *Olcostephanus* and *Stephonoceras*—a good example of heterochronous homœomorphy, a phenomena now known as often occurring in the Cephalopoda.

*Vascoceras*³⁾ is a genus lately proposed by P. CHOFFAT to include Ammonites intermediate between *Olcostephanus* and *Acanthoceras* (*Mammites*). According to this author, *Amm. superstes* differs from *Vascoceras* in respect of the higher saddles

1) KOSSMAT: l.c. p. 133, pl. XVII., figs. 1 a, b, c.

2) KOSSMAT: l.c. p. 20.—STOLICZKA: l.c. p. 122, pl. LX. Further see NEUMAYR: l.c. p. 933.

3) CHOFFAT: Faune Crétacique du Portugal, II Série. P. 51.

of the suture line, while GROSSOUVRE¹⁾ considered it to be a species rather referable to the genus *Acanthoceras*. Thus, the question in regard to the particular generic name that should be retained for the group under consideration seems at present an open one.

Ammonites rudra occurs in the middle, and *Amm. superstes* in the upper division of the Utatur group of South India. According to PERON²⁾ and CHOFFAT, Ammonites closely resembling the latter occur also in the deposits of the Turonian age of Algeria and Portugal. *Ammonites (Buchiceras) Hartii* HYATT from the upper Cretaceous of Sergipe in Brazil which has been referred by KOSSMAT to the same group, together with the above two species, shows also a close relation to *Vascoceras*, but the specimen in this case seems too imperfect for the decision of its proper generic position.

AMMONITES KOTOI M.

Pl. VI., figs. 3 and 4.

The only specimen here figured is an imperfect cast of the interior in which only a portion of the outer volution is well preserved. The suture line, however, is tolerably well preserved.

Shell globose, inflated, consisting of many volutions. Umbilicus deep, moderate in breadth. Whorls lunular in cross-section, broader than high; uniformly rounded on the ventral and lateral sides. Surface with numerous transverse ribs, and a

1) GROSSOUVRE: Sur *P. Ammonites peramplus*, p. 334.

2) PERON: Les Ammonites du Cretacé supérieur de l'Algérie, p. 14.—KOSSMAT: l.c. p. 135.

row of tubercles bordering the umbilicus. Ribs round, simple and uniform, separated by intervals of like breadth, gently curving forward on the ventral surface of the whorl and generally bearing a moderately sized tubercle on the umbilical margin. Umbilical wall perpendicular and smooth.

The volution next to the outer one differs from it mainly in having a relatively wider umbilicus.

The siphonal saddle is broad and high, flat on the top, and with a few denticles on both sides. The external and the first lateral saddles are exceedingly high and simple, with a few short branches, and are tripartite on the top. Each branch terminates in a round lobule. The first lateral lobe is bifid and somewhat shorter than the external one.

As already mentioned, the present species is an ally of *Amm. superstes* and *Amm. rudra*; of these two, it exhibits a greater resemblance to the first than to the second. However, it differs from the first by its higher whorl bearing more numerous ribs and tubercles.

Locality:—The specimen was found in a nodule of marl, obtained as a pebble in the Yūbarigawa. This being the sole example now at the writer's disposal, its stratigraphical position cannot be given with any certainty.

OLCOSTEPHANUS NEUMAYR.

NEUMAYR¹⁾ correctly remarked that an *Ammonites* from Urakawa brought under the genus *Stephanoceras* by BRAUNS²⁾

1) NEUMAYR: Neues Jahrb. für Mineralog. Geolog. u. Paläontolog. 1881 Bd. II., p. 80.

2) BRAUNS: Vorläufige Notiz über Vorkommnisse der Juraformation in Japan.

might belong to *Olcostephanus*, while NAUMANN¹⁾ believed it to be in reality a specimen, foreign to Japan. In the JIMBŌ collection, however, there is a specimen of Ammonites referable, as the present writer believes, to *Olcostephanus*, with a label written "Loc. Takambe, a branch of the Ikushumbets river." Thus, at present there is no doubt about the occurrence of the Ammonites of the above named genus in our fauna.

A specimen described by JIMBŌ²⁾ as a species of *Olcostephanus*, long ago, is now believed by the present writer to be merely an imperfect specimen of a new species of *Scaphites* which will be described in some detail in the succeeding part of this memoir.

OLCOSTEPHANUS UNICUS M.

Pl. VI., figs. 5, a, b.

Dimensions :—

Diameter.	4.2 mm.
Height of the last whorl.	1.9 „
Breadth of the last whorl.	2.3 „
Width of umbilicus.	1.2 „

Shell composed of many volutions, inflated. Umbilicus moderate in size, deep; the umbilical wall is perpendicular and its margin rounded. Aperture subrescentic, broader than high, uniformly rounded on the lateral as well as on the ventral side. Involution rather deep. Surface with numerous transverse ribs; straight, uniform, narrow but prominent, separated by flat intervals wider than their breadth. The ribs are closely set and nearly

1) NAUMANN: Ueber das Vorkommen der Kreideformation auf der Insel Jezo.

2) JIMBŌ: l.c. p. 33 (179), pl. IX., figs. 3, a, b.

parallel to one another, while near the umbilical margin, three or more of them unite to form a bundle. Besides, there are five constrictions on the last volution which are broader and deeper than other intervals and are bordered behind by a rib somewhat more prominent than the usual ribs to which they are arranged quite parallel.

The suture line which is only partly seen, shows three saddles. The first lateral saddle is narrow, but high and bipartite; the lobes are also bipartite.

Of Ammonites described from the Cretaceous deposits of the Pacific border, *Olcostephanus Logannianus* WHITEAVES¹⁾ from the Chorizon of the Queen Charlotte Islands in some respects appears nearest to this species. The periodic ribs seen on the Japanese specimen are not present in the American species, and moreover the whorls of the former increase as the shell grows more rapidly than the latter.

Locality:—The specimen here figured is from the Kamitakambe, a right branch of the Ikushumbets, between the Poronai and the Ikushumbets coal mines.

Horizon:—Unknown.

HAUERICERAS GROSSOUVRE.

The genus *Hauericeras* was established by A. DE GROSSOUVRE,² in 1893, to include Ammonites which have smooth, strongly compressed, discoidal shells, with a sharp, ventral keel and having the suture line composed of two broad saddles followed by 3-7

1) WHITEAVES: Mes. Foss. Vol. I., pt. 1, p. 27, text fig. 3; pl. VIII., fig. 2. Pt. 3, p. 211, pl. XXIII., figs. 1 and 1a. Pt 4, p. 276.

2) GROSSOUVRE: Recherches sur la Craie supérieure. 1893. P. 219.

smaller ones. The external and lateral saddles are unequally bipartite and especially so in the former, so that it may more properly be called tripartite; the lateral lobe is also broad and tripartite, and about as long as the external one. The siphonal saddle is relatively high and broad, being inflated at the top. The auxiliary saddles and lobes rapidly diminish in size and hang obliquely toward the umbilical suture.

KARL V. ZITTEL¹⁾ treats *Hauericeras*, *Desmoceras*, *Puzosia* and *Pachydiscus* under the family of Desmoceratidae, while GROSSOUVRE²⁾ brings them together with *Schlüteria* under the family of Phylloceratidae. AL. HYATT³⁾ includes them, with the exception of *Pachydiscus*, in the family of Haploceratidae. However, the general character of *Hauericeras* in its developmental stages differs slightly from Phylloceratidae, being on the contrary closely allied to the typical *Desmoceras*, and therefore the writer is at a loss to see why GROSSOUVRE included it among the Phylloceratidae.

As is generally accepted by palæontologists, *Hauericeras* has a close affinity to the group of *Desmoceras Sugata* FORBES and also to the genus *Puzosia* BAYLE, the resemblance to the former being in its ventral keel, and to the latter in the suture line. The writer himself also at first adopted the same view, but a further examination of the specimens from the Hokkaidō led him to think that the latter belonged rather to the family of Phylloceratidae than to Desmoceratidae. He, of course, thinks it scarcely safe to determine their taxonomic position on such an external resemblance, and this question, consequently, may be treated, in some detail, in the later part of this memoir.

1) ZITTEL: Grundzüge d. Palæontologie 1895.

2) GROSSOUVRE: l. c. p. 163.

3) HYATT: Cephalopoda in ZITTEL's Text Book of Palæontology translated by EASTMAN. 1899. P. 569.

No matter to what family our genus belongs, it is, undoubtedly one of the most important groups of Ammonites for stratigraphical purposes, as though much restricted in the number of species its geographical distribution is very wide.

The type of the genus is *H. Gardeni* BAILY sp.,¹⁾ recognized in the Cretaceous (horizon f. of GRIESBACH) of Natal in South Africa, the Ariyalur and Trichinopoly groups of South India, the Nanaimo group (Horizon B of RICHARDSON) of Vancouver, and the Cretaceous of the Hokkaidō. To the same species, an Ammonites from the Cretaceous of Tunis has lately been referred by PERVINQUIERE²⁾ although with some doubt, and *Ammonites sulcatus* KNER³⁾ from Galicia is by some palæontologists taken as a synonym of *H. Gardeni*. If the above determinations are correct, then it is a cosmopoliton species of the upper Cretaceous Ammonites.

According to GROSSOUVRE and KOSSMAT, this genus also includes *Ammonites rembda* FORBES, *Amm. pseudogardeni* SCHLÜTER, *H. Fayoli* GROSS. and *H. Welschi* GROSS. *H. rembda*⁴⁾ occurs in the Valudayur bed of South India, the Cretaceous of Natal (horizon d) and Madagascar⁵⁾ while *Amm. pseudogardeni*⁶⁾ is found in the zone of *Scaphites binodosus* of the German Cretaceous. *Amm. pseudogardeni* var. *nodotum* SCHLÜTER⁷⁾ from Braunschweig

1) Vide p. 32.

2) L. PERVINQUIÈRE: Un faciès particulier du Sénoïen de Tunisie. 1895. (By review).

3) FAVRE: Descrip. des Mollusques foss. la craie des environs de Lemberg 1869. P. 12, pl. IV., fig. 7.

4) STOLICZKA: Foss. Ceph. Cret. Rock South India. P. 63, pl. XXXIII., fig. 5; pl. LXXI., fig. 9. GRIESBACH: Geol. of Natal. P. 63, pl. III., figs. 2, 3. KOSSMAT: Unters. ü. d. Südind. Kreidefom. P. 124, pl. XVIII., fig. 9.

5) GROSSOUVRE: Sur quelques Fossiles Crétacés de Madagascar. p. 378, 1899.

6) SCHLÜBER: Cephal. d. oberen deutsch. Kreide, p. 54, pl. XVI., figs. 3-6.

7) SCHLÜTER: Podocrates im Senon von Braunschweig. Zeitsch. d. deut. geol. Gesell. Bd. LI., p. 411.

has not yet been fully illustrated and the specific identification seems to be uncertain. Of the two species described by GROSSOUVRE from the Cretaceous of France, viz. *H. Fayoli*¹⁾ and *H. Welschi*,²⁾ the former is in the Campanien and the latter in the zone of *Mortoniceras texanum*.

The present writer proposes to bring two other species under this genus. The one is *Amm. lagurus* REDTENBACHER³⁾ from Gossau which shows such agreement in every particular with the above mentioned typical species that the writer has no hesitation in stating their generic identity. The other is a new form found in the Cretaceous of the Hokkaidō, and is described below under the name of *H. angustum*.

HAUERICERAS GARDENI BAILY.

1855. *Ammonites Gardeni* BAILY : Cret. Foss. South Africa, p. 456, pl. XI., fig. 3.
1865. *Amm. Gardeni* STOLICZKA : Foss. Ceph. Cret. Rock S. India, p. 61, pl. XXXIII., fig. 4.
1879. *Amm. Gardeni* WHITEAVES : Més. Foss. vol. I., pt. 2, p. 102.
1880. *Haploceras Gardeni* NAUMANN : Kreidef. auf der Insel Jezso, p. 10.
1890. *Desmoceras Gardeni* YOKOYAMA : Verst. Jap. Kreide, p. 184, pl. XX., fig. 10 a-c.
1895. *Desmoceras Gardeni* WHITEAVES : On some Foss. from the Nanaimi Group of the Vancouver Cret. p. 131.

1) GROSSOUVRE: l.c. p. 221, pl. XXVII., fig. 3.

2) GROSSOUVRE: l.c. p. 222, pl. XXXV., fig. 9.

3) REDTENBACHER: Cephalopoden Fauna d. Gosauschichten, p. 112, pl. XXV., figs. 3 a, b.

1895. *Desmoceras Gardeni* WHITEAVES : On some Foss. from the Nanaimo Group of the Vancouver Cret. P. 131.
1895. *Hauericeras Gardeni* GROSSOUVRE : Les Ammonites de la Craie supérieure. P. 220.
1897. *Hauericeras Gardeni* KOSSMAT : Unters. ii. d. S. Ind. Kreidef. P. 123 pl. XVIII. figs. 7 a, b, 8, 10.
1903. *Hauericeras Gardeni* WHITEAVES : Mes. Foss. vol. I., pt. 5, p. 352.

The remarks of YOKOYAMA on the Japanese specimens given in the above quoted work need no special additions, and everyone who sees his figure is at once convinced that the Japanese form must be identified with that of South Africa.

Localities :—Urakawa and Chashikots in Ikandai near Urakawa, Hidaka Prov.; the Sanushibe and the Shirikuru-pokomanai, in the Sōshibets, both branches of the Mukawa, Iburi Prov.; the Shi-kuruki, a tributary of the Yūbarigawa and the Kikumezawa, a tributary of the Ikushumbets, Ishikari Prov.; the Opiraushibets and the Abeshinai, a tributary of the Teshiogawa, both in Teshio Prov.; north of Chietomanai near Cape Sōya, Kitami Prov. Although this species is found everywhere in the *Pachydiscus*-beds, the number of its individuals is always limited.

HAUERICERAS ANGUSTUM M.

Pl. V., figs. 5, 6.

In the JIMBŌ collection, there are two other specimens of *Hauericeras* showing an aspect distinct from the preceding species. Both are small but beautifully preserved, one of them showing

the suture lines in detail up to the end of the outer volution. In the writer's collection, there are also two specimens, referable to the same species; one of them is somewhat larger and flattened on the sides by pressure, but agrees in point of essential characters with the above examples.

The dimensions of these three examples measured are as follows :—

	(1)		(2)		(3)	
		Ratio.		Ratio.		Ratio.
Diameter.	3.65 cm.	100	3.45 cm.	100	2.60 cm.	100
Height of the last whorl.	1.50 "	41	1.35 "	39	1.10 "	42
Breadth of the last whorl.	—	—	0.75 "	22	0.55 "	21
Width of umbilicus.	1.15 "	31	1.10 "	31	0.85 "	32
Involution.				$\frac{1}{9}$		

1). A specimen from the Kikumezawa.

2). " " " " Urakawa; (pl. V., fig. 5.)

3). " " " " Urakawa.

As is seen from the above table, the variation is very slight in the three specimens except in size.

This species is readily distinguished from *H. Gardeni* BAILY,¹⁾ *H. rembda* FORBES²⁾ and *H. Fayoli* GROSSOUVRE³⁾ by its narrower umbilicus and higher whorl. It is, no doubt, much like *H. Welschi* GROSSOUVRE,⁴⁾ with which at first glance it seems to agree in nearly all its characters. But a closer examination reveals a marked difference in the form of the whorl. In the Japanese species the lateral sides converge gradually upward to the ventral keel, while in the GROSSOUVRE's figure of *H. Welschi*, the sides converge very slowly to the ventral margin whence they suddenly bend to the base of the keel.

1) See p. 32.

2) l.c.

3) l.c.

4) l.c.

This species agrees tolerably well with *H. Gardeni* in its suture line, there being in both four auxiliary saddles. That *H. pseudogardeni* differs from the present species notwithstanding their great resemblance in external shape is easily seen in that it has more numerous auxiliaries.

Localities:—The Kikumezawa, a tributary of the Ikushumbetsu, Ishikari Prov.; the Popetsu, a branch of the Mukawa, Iburi Prov.; Urakawa, Hidaka Prov.

Horizon:—The only case in which the mode of occurrence of this species has been determined, is in the Kikumezawa, where it was found in the *Pachydiscus*-beds together with *H. Gardeni*.

DESMOCERAS ZITTEL.

DESMOCERAS DAWSONI WHITEAVES var. JAPONICA.

Pl. V., figs. 3, 4.

1884. *Haploceras Beudanti* WHITEAVES: Mes. Foss., vol. I., pt. 3, p. 205, pl. XXVI., figs. 1 and 1a.

1900. *Desmoceras (Puzosia) Dawsoni* WHITEAVES. Mes. Foss., vol. I., pt. 4, p. 286, pl. XXXVII., fig. 3.

The specimens of this species in the writer's collection, excepting one which has been figured, are more or less distorted by pressure. The suture line is also quite obscure on account of the bad state of preservation.

Dimensions :

	(1)	Ratio.	(2)	Ratio.	(3)	Ratio.
Diameter.	11.3 cm.	100.	11.1 cm.	100.	13.2 cm.	100.
Height of the last whorl.	5.7 "	50.	5.5 "	49.	6.8 "	51.
Breadth of the last whorl.	4.5 "	38.	3.3 "	29.	—	—
Width of umbilicus.	2.1 "	16.	—	—	2.35 "	18.

- 1). The figured specimen from the Ikushumbets.
- 2). *Desmoceras Dawsoni* WHITEAVES from Cumsheewa Inlet; measured from the figure on Pl. XXVI. in Mes. Foss. vol. I., pt. 3.
- 3) *Desmoceras Dawsoni* WHITEAVES from Cumsheewa Inlet; measured from the figure on Pl. XXXVII. in Mes. Foss. vol., I., pt. 4.

Shell discoidal, compressed on the sides and rounded on the ventral surface. Umbilicus narrow, with a steep wall and more or less rectangular margin. Involution very deep, about $\frac{5}{6}$ of each volution being covered. Section of the whorl elliptical, higher than broad. Surface with eight distant, very flexuous constrictions, parallel to the lines of growth. Constrictions narrow, bordered behind by an elevated rim which becomes more prominent and bends strongly forward on the ventral surface. On aged specimens, these constrictions become strongly sigmoidal as is shown in the anterior portion of the figured example, and the lines of growth, otherwise appearing as delicate striæ, also become coarser.

The suture line is only partly visible. The first lateral lobe is about as long as the external lobe and tripartite, but not so deep and wide as in the case of *Puzosia*. The external saddle as well as the two lateral ones are bipartite.

The general outline, surface marking and suture line of the Japanese species much resemble those of *Desmoceras Dawsoni*

WHITEAVES from the Queen Charlotte Islands. But the shell is somewhat broader and periodic constrictions are less numerous in the Japanese species, so that the writer feels warranted in proposing a new specific name for it.

According to WHITEAVES, *Desmoceras Dawsoni* is quite abundant in the Cretaceous rocks on the northern shore of Cumshewa Inlet, while in Bear Skin Bay a few specimens are said to occur which are however distinguished from the typical form by their rectangular umbilical margin. The latter is considered by that author as a variety to which the Japanese form seems to approach more closely.¹⁾

At first, WHITEAVES²⁾ identified his specimens with a European form—*Ammonites Beudanti* BRONGNIART—which is also recorded by STOLICZKA as occurring in the South Indian Cretaceous fauna.³⁾ Afterwards, however, KOSSMAT⁴⁾ proved the distinction between *Amm. Beudanti* and the allied form from South India. The latter, as described by him, shows the suture line of the type of *Puzosia*, and hence it is a species quite different from *Ammonites Beudanti* which no doubt belongs to *Desmoceras*. He stated also that *Ammonites Beudanti* of WHITEAVES from the Queen Charlotte Islands is a true *Desmoceras*. This view was afterward adopted by WHITEAVES⁵⁾ himself who in his later publication made a new specific name for what he had formerly taken for *Ammonites*

1) J. C. MERRIAM later reported this species from Spanisch Gulch of the John Day Basin.

2) D'ORBIGNY: Ter. Crétacés. Ceph. P. 278, pl. XXXIII., XXXIV. 1840.—PICTET: Moll. des Grès Verts. P. 33, pl. II., fig. 3. 1848.—QUENSTEDT: Ceph. P. 222, pl. XVII., fig. 10. 1849.—PICTET et CAMPICHE: S. Croix. P. 277, pl. XL., figs. 1-4. 1860.—PARONA e BONARELLI: Fossili albiani d'Escagnolles. P. 86 (34), pl. XI. (II.), fig. 6. 1896.

3) STOLICZKA: Foss. Ceph. Cret. Rock South India. P. 142, pl. LXXI., figs. 2-4; pl. LXXII. 1865.

4) KOSSMAT: Süd. Ind. Kreidef. P. 120 (185). 1897.

5) WHITEAVES: Mes. Foss. Vol. I. pt. 4, P. 286. 1900.

Beudanti, giving the Characters which distinguish it from *P. Stoliczkai* KOSSMAT of Southern India. However, he differs from KOSSMAT in one point; viz. in referring his species not to *Desmoseras*, but to *Puzosia*, in which respect the present writer is more inclined to adopt the opinion of KOSSMAT.

The reason why the present writer hesitates to bring this species under *Desmoceras* is because its suture line is only imperfectly known. KOSSMAT who examined the Canadian specimen, thinks that it has a typical *Desmoceras* suture as he says "mit ganz typischer zur Naht gehender Lobenlinie." A part of the suture line seen on a Japanese specimen gives no clue to distinguish it from *Desmoceras*. On the other hand, the suture line on pl. XXVI in the WHITEAVES' monograph which does not appear to be very satisfactorily drawn, shows in some respects a resemblance to that of *Cleonicerias*,¹⁾ a genus proposed by PARONA and BONARELLI to include *Amm. Cleon.* d'ORB., formerly assigned to *Sonneratia*, *Amm. Beudanti* and a few other allied forms. Such being the case, it is quite impossible at present to determine whether this species is *Desmoceras* or *Cleonicerias*.

Desmoceras Dawsoni shows also a distant relation to *Desmoceras voyi* Anderson²⁾ from the Horsetown beds of California. The latter possesses, however, a broader and somewhat inflated shell with lateral sides gently converging to the ventral surface, and although the periodic ribs are of the same nature as those of *Desmoceras Dawsoni*, yet they are fewer in number. The suture line is described as agreeing with that of *Desmoceras latidorsatum* MICHELIN.³⁾

1) PARONA e BONARELLI: Fossili albiani d'Escagnolles, p. 85 (33). 1896.

2) ANDERSON: Cret. Dep. Pacific coast, p. 100, pl. III., figs. 89, 90, 1902.

3) D'ORBIGNY: l.c. p. 270, pl. LXXX.—PICTET: Foss. d. Gres. Verts. p. 44, pl. III., figs. 4, 5.—STOLICZKA: l.c. p. 148, pl. LXXIV., figs. 1-4.—KOSSMAT: l.c. p. 107 (172), pl. XIX (XXV), figs. 2-5.

The occurrence of *Desmoceras Dawsoni* in the Cretaceous of the Hokkaidō is of special importance, as among the few Japanese forms which show some relation to those of the North American Pacific species, none is more closely related than the present one, and it is also a remarkable fact that a bivalve, very much like *Thetis affinis* WHITEAVES¹⁾ from the C horizon of the Queen Charlotte Islands is found abundantly together with this Ammonites in the same layers.

Locality and horizon :—Several specimens of this Ammonites, one of which is here figured, were obtained along the Ikushumbets 10 miles east of the Ikushumbets coal mines, Ishikari Prov. Up to this time it has been met with only at the above locality where it is quite numerous in a sandstone of the *Thetis*-zone, associated with *Thetis* aff. *affinis* WHITEAVES.

DESMOCERAS PORONAICUM M.

Pl. VI., figs. 1, 2.

Dimensions :—

		Ratio.
Diameter.	2.5 cm.	100.
Height of the last whorl.	1.2 „	48.
Breadth of the last whorl.	1.1 „	44.
Width of umbilicus	0.4 „	16.

Shell small, discoidal, composed of a few compressed whorls, which are nearly parallel sided and slope gradually to the rounded ventral surface. Involution very deep; umbilicus narrow with the perpendicular wall, exposing only a very small portion

1) WHITEAVES: Mes. Foss. vol. I., pt. 3, p. 226, pl. XXX., figs. 4, 4 a, b; pt. 4. p. 290.

of the inner whorls. Aperture somewhat elongated, higher than broad. Surface of the shell apparently quite smooth, with a faint groove on a portion of the anterior whorl where the shell has been taken off. The groove curves strongly forward in crossing the ventral surface where it is more distinct than on the lateral sides. Suture line with four saddles and four lobes on each lateral side, and the two on the umbilical wall. These saddles and lobes diminish very gradually in size and are all similar in shape, the former being bipartite and the latter tripartite excepting the three or four innermost ones which are always simple.

There is scarcely any doubt as to the existence of a close relationship between this species on the one hand and *Desmoceras inane* STOLICZKA¹⁾ from the Utatur Group and *D. diphylloides* FORBES²⁾ from the Ariyalur and the Voludayur group of S. India on the other. *D. diphylloides* agrees fairly well with this species in its general outline if we except the slightly narrower umbilicus and more numerous saddles and lobes. *D. inane* is thicker than the Japanese species although it much resembles it in the suture line. *Ammonites Selwynianus* WHITEAVES³⁾ from the Horizon A of Vancouver Island and *D. pyrenaicum* GROSSOUVRE⁴⁾ from the Santonien of France are also our distant allies.

From *D. Dawsoni* WHITEAVES var., the present species is distinguished by the higher whorls and narrower umbilicus. But as the specimens of these two species examined by the writer are quite different in size, the above distinctions must be taken

1) STOLICZKA: l.c. p. 121, pl. LIX., fig. 13 (non fig. 14).—KOSSMAT: l.c. p. 107, pl. XIX., figs. 6-7.

2) STOLICZKA: l.c. p. 119, pl. LIX., figs. 8-9.—KOSSMAT: l.c., p. 108, pl. XIX., figs. 8-9.

3) WHITEAVES: l.c. pt. 2, p. 104, pl. XIII., fig. 1; pt. 5, p. 351.

4) GROSSOUVRE: Ann. de la Craie supérieure, p. 168, pl. XXXVII., figs. 9 a, b, c.

with some reserve. Also it may not be impossible, as it sometimes happens, that they are really individuals of one and the same species at different stages of growth. However, for the present, it seems preferable to treat them as two distinct species.

Locality and horizon:—This species is known only from two small, probably immature specimens, obtained near the source of the Poronai, Ishikari Prov. At this place, they were found in a pebble of a marly module, the exact horizon in which they occur being unknown, but it is almost certain that the nodule was derived either from the lower part of the upper Ammonite-beds or from a layer below it.



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H. YABE.

CRETACEOUS CEPHALOFODA FROM THE HOKKAIDŌ.

PLATE I.

Turrilites.

Plate I.

Turritiles Komotai m. Pp. 7-9.

Fig. 1. Side view of the type, preserved in the Sci. Coll. Mus. From lower
Acanthoceras-zone of the Ikushumbets, Ishikari Prov. Nat. size.



Fig. I.

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CRETACEOUS CEPHALOPODA FROM THE HOKKAIDŌ.

PLATE II.

Turrilites.

Plate II.

Turritites Komotai m. Pp. 7-9.

Fig. 1. Upper view of the specimen drawn in Pl. I.



Fig. 1.

H. YABE.

CRETACEOUS CEPHALOPODA FROM THE HOKKAIDŌ.

PLATE III.

Turrilites, Helicoceras and Heteroceras.

Plate III.

(All the specimens here figured are in Sci. Coll. Mus.)

Turritiles aff. *Bergeri* B&G. Pp. 4-7.

Fig. 1. Side view of the type. From lower Ammonite-beds of the Popets, Iburi Prov. Nat. size.

Helicoceras scalare m. Pp. 9-10.

Fig. 2. Upper view of the type. From *Scaphites*-beds of the Opiraushibets, Teshio Prov. Nat. size.

Figs. 3 a, b, c. Upper and lower views and cross-section of another specimen. From *Scaphites*-beds of the Opiraushibets. Nat. size.

Helicoceras venustum m. Pp. 11-12.

Fig. 4. Side view (slightly oblique) of a large specimen. From *Scaphites*-beds of the Opiraushibets. Nat. size.

Heteroceras Ōshimai m. Pp. 12-14.

Fig. 5. Side view of the type. From upper Ammonite-beds of the Ikushumbets, Ishikari Prov. Nat. size.

Fig. 6. Side view of a smaller specimen. From upper Ammonite-beds of the Shikuruki, Ishikari Prov. Nat. size.

Heteroceras orientale m. Pp. 19-20.

Fig. 7. Side view of the type. From the upper Ammonite-beds of Ura-kawa, Hidaka Prov. Nat. size. In this drawing, the larger end of the shell is shown below and the smaller end above.

Heteroceras japonicum m. Pp. 17-18.

Fig. 8. Side view of the type. From upper Ammonite-beds of the Yūbarigawa, Ishikari Prov. Nat. size.

Heteroceras Ōtsukai var. *multicostata* m. Pp. 16-17.

Fig. 9. Side view of the type. From *Scaphites*-beds of the Opiraushibets. Nat. size. On this figure, the larger end of the shell is shown below and the smaller end above.



Fig. 8.



Fig. 7.

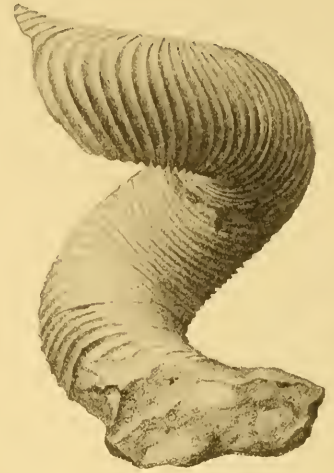


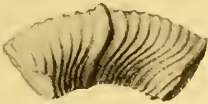
Fig. 9.



Fig. 2.



a.



b.



c.

Fig. 3.

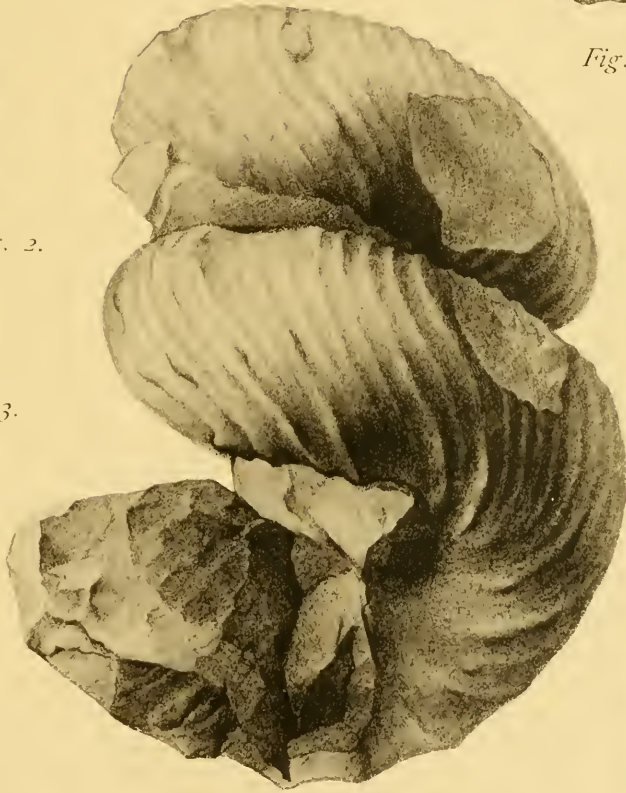


Fig. 5.

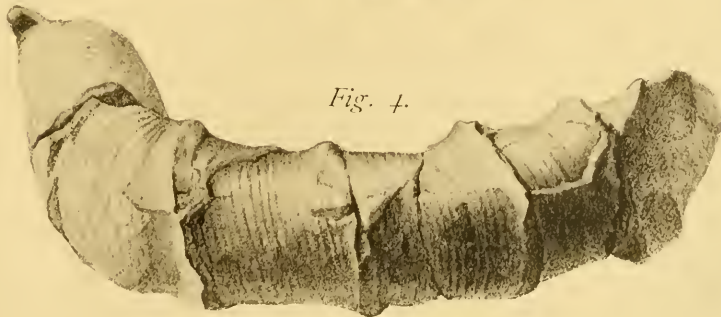


Fig. 6.

Fig. 1.



Fig. 4.



H. YABE.

CRETACEOUS CEPHALOPODA FROM THE HOKKAIDŌ.

PLATE IV.

Heteroceras and Nipponites.

Plate IV.

(All the specimens, here figured, are in Sci. Coll. Mus.)

Heteroceras Ōtsukai m. Pp. 14-16.

- Fig. 1. Side view of the type. From *Pachyliscus*-beds of the Kikumezawa, Ishikari Prov. Nat. size. Slightly restored. In this figure, the larger end of the shell is shown below and the smaller end above.
- Fig. 2. Side view of a portion of whorls of another specimen. From upper Ammonite-beds of the Yūbarigawa. The siphon comes nearer the lower margin toward the anterior end. Nat. size.

Heteroceras Ōtsukai m. var. *multicostata* m. Pp. 16-17.

- Fig. 3. Side view of a specimen with numerous ribs. From upper Ammonite-beds of the Yūbarigawa. Nat. size.

Nipponites mirabilis m. Pp. 20-25.

- Figs. 4 and 5. Views from two different directions of the type. From upper Ammonite-beds of the Opiraushibets.
- Fig. 6. Cross-section of the same. Nat. size. s. siphon.
- Fig. 7. Wire-model to show the mode of the coiling the whorls.



Fig. 3.

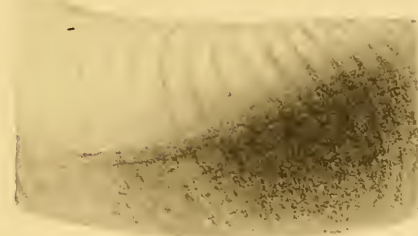


Fig. 2.



Fig. 6.

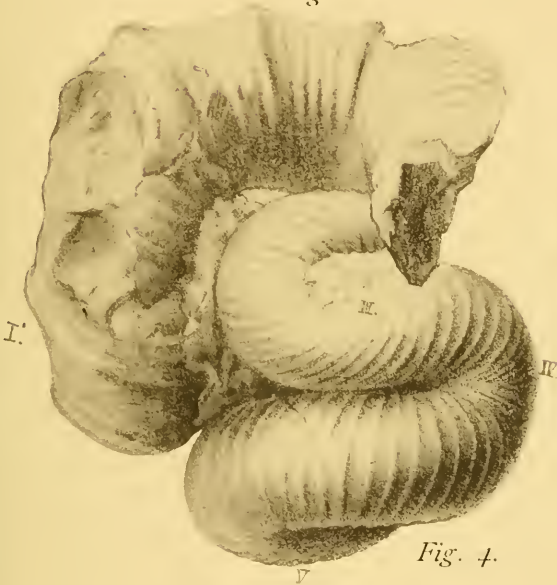


Fig. 4.



Fig. 5.

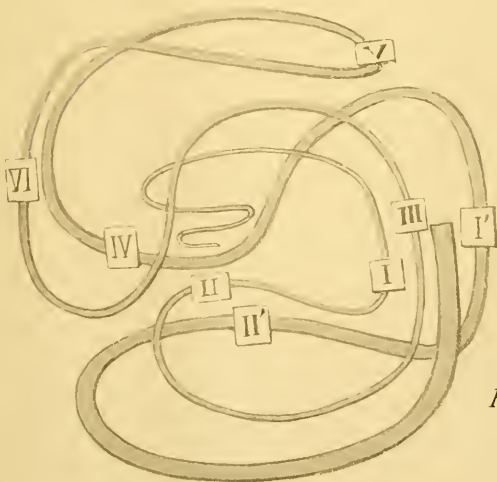


Fig. 7.

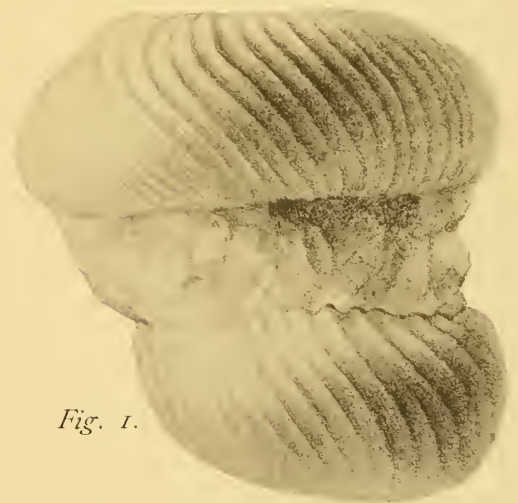


Fig. 1.

H. YABE.

CRETACEOUS CEPHALOPODA FROM THE HOKKAIDŌ.

PLATE V.

Helicoceras, Desmoceras and Hauericeras.

Plate V.

(All the specimens, here figured, are in Sci. Coll. Mus.)

Helicoceras venustum m. Pp. 11-12.

- Fig. 1. Upper view of the type. From *Pachyliscus*-beds of the Sanushibe, Iburi Prov. Nat. size.
Fig. 2. Diagram of a suture line, drawn from the same specimen. s. siphonal line. $\times 4$.

Desmoceras Dawsoni WHITEAVES var. *japonica*. Pp. 35-39.

- Figs. 3 a, b. Side and front views of the type from the *Thetis*-zone of the Ikushumbets. Nat. size.
Fig. 4. Diagram of a suture line, drawn from another specimen. Nat. size.

Hauericeras angustum m. Pp. 33-35.

- Figs. 5 a, b. Side and front views of the type. From the Upper Ammonite-beds of Ikandai, near Urakawa. Nat. size.
Fig. 6. Diagram of a suture line, drawn from the same specimen. s. siphonal line; u. m. umbilical margin. $\times 4$.

Fig. 1.



Fig. 2.

Fig. 4.



a. b.
Fig. 5.



Fig. 6.

Fig. 3.

a. b.



H. YABE.

CRETACEOUS CEPHALOPODA FROM THE HOKKAIDO.

PLATE VI.

Desmoceras, Olcostephanus, Nipponites, Heteroceras
and an undetermined Genus.

Plate VI.

(All the specimens, here figured, are in Sci. Coll. Mus.)

Desmoceras poronaiicum m. Pp. 39-41.

Figs. 1 a, b. Side and front views of the type from the Upper Ammonite-beds of the Poronai, Ishikari Prov. Nat. size.

Fig. 2. Diagram of a suture line, drawn from the same specimen. s. siphonal line; u.m. umbilical margin. $\times 3$.

Ammonites Kotoi m. Pp. 26-27

Fig. 3. Side view of the type. From the Yūbarigawa. Slightly restored. Nat. size.

Fig. 3 a. Cross-section of the whorl. Nat. size.

Fig. 4. Diagram of the suture line, drawn from the same specimen. s. siphonal line; u.m. umbilical margin. $\times 2$.

Olcosteplianus unicus m. Pp. 28-29.

Figs. 5 a, b. Side and front views of the type. From the Takambets, Ishikari, Prov. Nat. size.

Nipponites mirabilis m. Pp. 20-25.

Fig. 6. Diagram of a suture line, drawn from the specimen figured in Pl. IV. s. siphonal line. Nat. size.

Heteroceras Ōtsukai m. Pp. 14-16.

Fig. 7. Diagram of a suture line, drawn from the specimens figured in Pl. IV., fig. 2. s. siphonal line. Nat. size.

Heteroceras Ōtsukai var. *multicostata*. Pp. 16-17.

Fig. 8. Diagram of a suture line, drawn from the specimen figured in Pl. IV., fig. 3. s. siphonal line; a.s. antisiphonal line. $\times 2$.

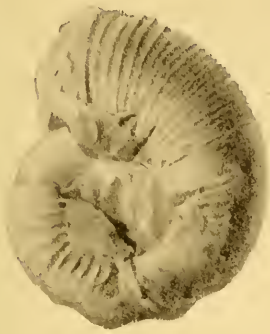


Fig. 5a.



Fig. 5b.

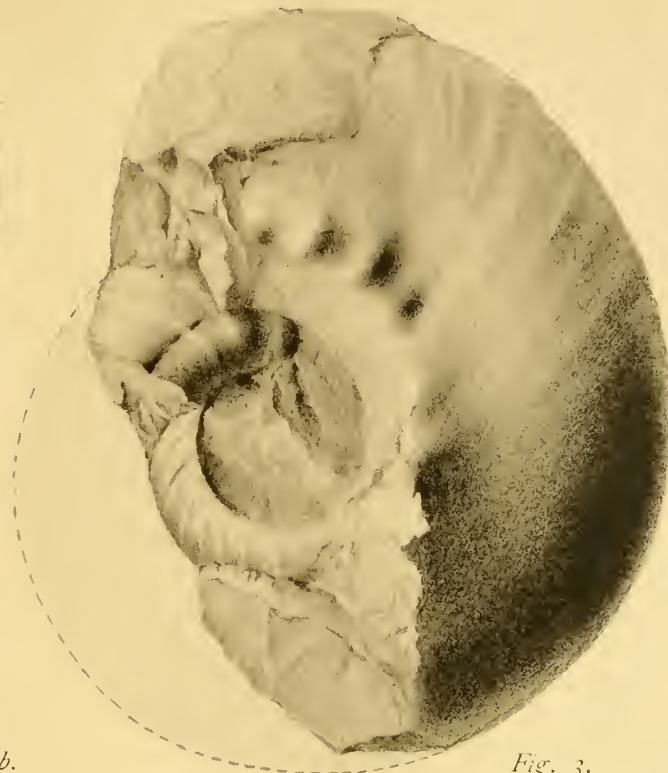


Fig. 3.



Fig. 1a



Fig. 1. 6.



Fig. 6.



Fig. 2.

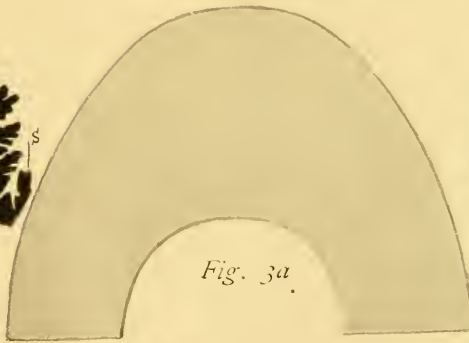


Fig. 3a.



Fig. 7.



u.m.

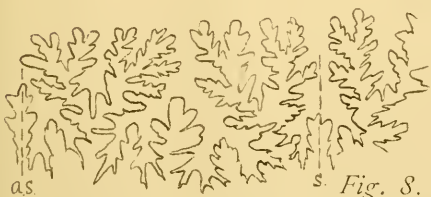


Fig. 8.



Fig. 4.

JOURNAL OF THE COLLEGE OF SCIENCE, IMPERIAL UNIVERSITY,
TOKYO, JAPAN.

VOL. XX., ARTICLE 3.

**Revisio Euphorbiacearum et Buxacearum
Japonicarum.**

auctore

B. Hayata.

cum tabulis 6.

Collectiones plantarum quae hujus operis fundamentum efficiunt, in Universitatis imperialis Tokyensis herbario servantur. Toto corde gratias publice ago viris doctissimis, qui peritissimis consiliis magnum mihi auxilium præbuerunt. Imprimis vero, me illustrissimo Prof. Dri. J. MATSUMURÆ, qui curam adhibuit maximum ad hoc meum opus, gratiam maximam debere profiteor.

EUPHORBIACEÆ.

Conspectus Generum.

Ovula in loculis gemina.

Embryo magnus, parce minor quam albumen.

Sepala ♂ imbricata.

Folia indivisa.

Fl. ♂ ad nodos v. axillas glomerati.

Styli erecti v. recurvi, tennes v. apice solo dilatati, cocci 2-valvati v. bacca 3-locularis.

Rudimentum ovarii evolutum.

Seminum testa tenuis ventrie non cava. Embryo rectus.

.....1. *Securinea*.

Seminum testa crustacea ventre duplicata inter lamina cava. Embryo incurvus.

.....2. *Fluvagea*.

Rudimentum ovarii 0.

Discus evolutus.3. *Phyllanthus*.

Discus 0.

Capsula. Calyx ♂ dilatatus. ...4. *Glochidion*.

Bacca. Calyx ♂ turbinatus lobis v. dentibus 6 inflexis fere clausus.5. *Breynia*.

Styli valde dilatati, patentes. Frutus drupaceus, indehiscens, abortu 1-spermus.6. *Putranjiva*.

Fl. ♂ racemi.7. *Antidesma*.

Folia digitatim foliolata.8. *Bischofia*.

Sepala ♂ valvata.9. *Bridelia*.

Embryo parvus, albumine quater ad sexies brevior. 10.....*Daphniphyllum*.

Ovula in loculis solitaria.

Involucrum non cyathium.

Filamenta in alabastro apice inflexa.11. *Croton*.

Filamenta in alabastro erecta.

Fl. ♂ sepalis valvatis, apetalis. Spicæ v. racemi.

Filamenta non ramosa.

Antheræ subglobosæ v. oblongæ.

Stamina 16-20. Antherarum loculi a basi distincti primum penduli demum ascendentes, superne long-

- itudinaliter dehiscences. Filamenta libera.
 12. *Mercurialis*.
 Stamina numerosa. Antheræ prope basin dorsifixæ,
 loculis distinctis parallelis connectivo lato separatis
 v. connectivo parvo longitudinaliter dehiscentibus.
 Filamenta libera. 13. *Mallotus*.
 Stamina 8. Antheræ dorsifixæ, loculis distinctis
 parallelis longitudinaliter dehiscentibus. Filamenta
 basi brevissime in annulum connata. ... 14. *Alchornea*.
 Stamina numerosa. Antheræ dorsifixæ, connectivo
 latiusculo breviter ultra loculos producto, loculis
 lateralibus transverse didymis. Filamenta libera. ...
 15. *Cleidion*.
 Stamina 6-10. Antheræ terminales, breves, 4-loculares.
 Filamenta libera. 16. *Macaranga*.
 Antheræ vermiformes. 17. *Acalypha*.
 Filamenta ramosissima.
 Herbe. 18. *Ricinus*.
 Frutices. 19. *Homonoia*.
 Fl. ♂ sepalis imbricatis, petaliferi. Paniculæ corymbosæ.
 20. *Aleurites*.
 Fl. ♂ sepalis imbricatis, apetalis. Spicæ v. racemi.
 Fl. glomerato-fasciculati. 21. *Gelonium*.
 Fl. spicati v. racemosi.
 Calyx ♂ a basi 8-partitus. 22. *Excoccaria*.
 Calyx ♂ brevissime lobatus. 23. *Sapium*.
 Involucrum cyathium. 24. *Euphorbia*.

1. *Securinega* JUSS.

BAILLON, Hist. d. Pl. V. 241; BENTH. et HOOK. Gen.
 Pl. III. 275; PAX, in ENGL. et Prantl. Nat. Pfl.
 Fam. III. 5 18.

Flores dioici, apetalis. Fl. ♂: sepala 5, imbricata. Disci

glandulae 5, staminibus alterni. Stamina 5, sepalis alterna, filamentis liberis; antherae erectae, loculis distinctis parallelis longitudinaliter dehiscentibus. Ovarii rudimentum evolutum, apice 2-3-fidum. Fl. ♀: calyx maris. Discus integer. Ovarium 3-loculare, stylis distinctis, recurvis, 2-fidis, ovulis in loculis geminis. Capsula sicca, in cocos 2-valves dehiscens. Seminum testa membranacea minute reticulata, albumen carnosum; embryo centralis, cotyledonibus planis latis. Frutices ramosi. Folia alterna, integra. Flores ad axillas glomerati, ♂ numerosi, ♀ pauciores, pedicellati.

1. **S. fluggeoides** MUELL. ARG. (Tab. I. A.).——MUELL. ARG. in DC. Prodr. XV. 2, 450; FORBES et HEMSL. Ind. Fl. Sin. II. 426; HENRY, List. Pl. Form. in Trans. Asia. Soc. Jap. XXIV. suppl. 82; L. DIELS, Fl. centr. China, in Engl. Bot. Jahrb. XXIX. 426.

S. japonica MIQ. in Ann. Mus. Bot. Lugd.—Bat. III. 28; FRANCH. et SAVAT. Enum. Pl. Jap. I. 425.

Phyllanthus japonicus MUELL. ARG. in Linnæa XXXII. 16.
NOM. JAP. *Hitotsuba-hagi*.

Ramuli foliigeri 1-5 pedes longi, graciles subflexuosi. Stipulae ovatae, acuminatae, fuscae. Petioli 4-5 mm. longi. Folia 3-5 cm. longa, 1-2 cm. lata, oblongato-elliptica, obtusa, basi acuta, rigide submembranacea, supra lucida, subtus glaucescentia. Flores ♀ in fasciculis 2-8, ♂ numerosi. Pedicelli ♀ 5-10 mm. longi apice incrassati, ♂ 3-5 mm. longi, tenues. Calyx ♀ 2 mm.; ♂ 1½ mm. longus; sepalia oblongo-ovata, obtusa, margine latiuscule hyalina. Ovarii rudimentum cylindricum patule et breviter trifidum glabrum, 1-2 mm. longum. Ovarium globosum 1-2 mm. longum, 1½ mm. diametro aequans, glabrum; styli basi breviter connati, intus canaliculati, apice bilobi. Fructus primum plus minusve carnosus,

demum capsulari-aperiens, excarpio carnosio, endocarpio osseo. Capsulæ $4\frac{1}{2}$ mm. latæ, $3\frac{1}{2}$ mm. longæ subteretes. Semina obtuse trigona, levia, reticulata.

DISTRIB. In Japonia mediana et australi vulgaris.

HAB. Liu-kiu : Kumesima, leg. H. KUROIWA, anno 1898.

Kiushu : Kumamoto, anno 1901.

Hondo : prope Tokyo.

2. *Fluggea* WILLD.

WILLD. Sp. Pl. IV. 757 ; ENDL. Gen. Pl. 1122 ; BENTH. et Hook. Gen. Pl. III. 276 ; PAX. in Nat. Pfl. Fam. III. 5, 18.

Flores dioici apetalii. Fl. ♂ : Fl. ♀ : sepala 5, subpetaloidea, imbricata. Discus planus, annularis, dentatus. Ovarium 3-loculare ; styli distincti, recurvi, 2-fidi, ovula in loculis gemina. Fructus subsuccosus, pericarpio tenui indehiscente. Semina subtriquetra, dorso rotundata, testa crustacea duplicata inter laminas cava ; albumen haud copiosum, circa cavum incurvum ; embryo incurvus, cotyledonibus latiusculis planis.—Frutices. Folia alterna, disticha, petiolata, integerrima. Flores minimi, axillares, pedicellati.

1. **F. microcarpa** BLUME ; MIQ. Fl Ind. Bat. I-2, p. 356 ; Hook. f. Fl. Brit. Ind. V. 328 ; FORBES et HEMSL. Ind. Fl. Sin. II. 427 ; HENRY, List Pl. Form. 83 ; L. DIELS in Engl. Jahrb. XXIX. 427.

Securinega obovata MUELL. ARG. in DC. Prodr. XV-2, 449 ; BENTH. Fl. Austral. VI. 115.

Flueggea Sinensis "BAILL. Etude Gene. Euphorb. 592."

Phyllanthus Wightianus MUELL ARG. in *Linnaea* XXXII. 6.

P. virosus WILLD. Sp. Pl. IV. 578; ROXB. Fl. Ind. III. 659.

P. retusus ROXB. Fl. Ind. III, 657.

Chorizandra pinnata WIGHT Ic. Ind. or. t. 1994.

Nom. Jap. *Shima-hitotsubahagi*.

Frutices. Rami cinerascens v. griseo-pallidi, graciles, glabres, plus minusve acute tetragoni. Folia petiolata, stipitata, obovoidea, oblongo-elliptica, obtusa v. rotundata, basi acuta, costis secundariis 10–12, subtus glaucescentia, $2\frac{1}{2}$ –4 cm. longa, 1–2 cm. lata, petiolis 3–4 mm. longis. Fl. ♀ : sepala $1\frac{1}{2}$ mm. longa. Ovarium globosum, styli distincti, patuli, bifidi. Fructus globosus 3 mm. diametro æquans. Pedicelli fructigeri $2\frac{1}{2}$ mm. longi. Semina 2 mm. longa, $1\frac{1}{2}$ mm. lata.

DISTRIB. Tropica et subtropica Asia, tropica Africa Australiaque.

HAB. Formosa : Tam-tsui, leg. T. MAKINO, anno 1896; Kelung, leg. T. MAKINO, anno 1896; Kut-chhiob, leg. K. MIYAKE, anno 1899.

3. *Phyllanthus* L.

LINN. Sp. Pl. ed-2. 67; ENDL. Gen. Pl. 1120; MUELL.

ARG. in DC. Prodr. XV-2, 275; BAILL. Hist. d.

Pl. v. 252; BENTH. et Hook. Gen. Pl. III. 272;

PAX in Nat. Pfl. Fam. III-5, 18.

Flores monoici, apetali. Discus varius. Fl. ♂ : sepala 5–6, v. 4 distincta, v. rarius basi breviter connata, imbricata, plus minusve distincte 2-seriata, petaloidea. Stamina in centro flores 3, 2, v. 5, filamentis liberis v. in columnam centralem connatis; antherarum loculi paralleli v. divergentes, extrorsum longitudinaliter

v. horizontaliter dehiscentes. Rudimentum ovarii 0. Fl ♀ : calyx maris v. rigidior ; ovarium 3-v. 6-loculare ; styli distincti v. plus minus connati, integri sæpius 2-fidi, erecti v. recurvo-patentes, subulati, v. planodilatati, superne introrsum stigmatosi ; ovula in loculis gemina. Capsula sicca v. carnosa, demum sæpissime in 2 coccos 2-valves dissdians, rarius vix dehiscens. Semina transversim 3-angularia, dorso convexa, angulo interiore recta, erarunculata, testa membrancea v. crustacea ; albumen carnosum, embryo rectus v. leviter incurvus, cotyledonibus planis rectis.—Herbæ, frutices. Folia integerrima, alterna, disticha. Flores parvi, axillares v. ad nodos ramulorum glomerati, ♂ subsessilis v. distincte pedicellati, pauci, ♀ in eadem axilla v. in ramulo distincto pauci v. solitarii, longius pedicellati.

Conspectus Phyllanthorum Specierum.

Herbæ v. suffrutices.

Stamina 3.

Filamenta tota longitudine monadelpha v. superne brevissime libera.

Sepala 5.1. *P. Niruri*.

Sepala 6.....2. *P. urinaria*.

Filamenta libera, basi breviter connata.3. *P. simplex*.

Stamina 2.

Disci glandulæ liberæ.4. *P. Matsumurae*.

Disci glandulæ connatæ.5. *P. liukiensis*.

Frutices.

Stamina 2.6. *P. flexuosus*.

Stamina 5.7. *P. reticulatus*.

Arbores.8. *P. Niinamii*.

1. **P. Niruri** LINN. (Tab. I. B.).——LINN.S p. Pl. ed. -2, 1392 ; THUNB. Fl. Jap. 56 ; AITON, Hort. kewensis, V. 335 ; ROXB. Fl. Ind. 559 ; HOOK. et ARN. Bot. Beech. Voy. 210 ; SIEB.

et ZUCC. Fl. Jap. Fam. Nat. Sec. Prim. 144; WIGHT, Ic. Pl. Ind. or. t. 1894; MIQ. Fl. Ind. Bat. I-2, 369; BENTH. Fl. Hongk. 311; MUELL. ARG. in Linnaea XXXII. 43; GRISEBACH, Fl. Brit. West. Ind. 34; MIQ. Prol. 24; HEMSL. Bot. cent. Ameri. III. 104; MUELL. ARG. in DC. Prodr. XV-2, 406; HEMSL. in Voy. Challenger, Bot. I-2, 63, Part 3, 187; HILLEBRAND, Fl. Hawai, 402; HOOK. f. Fl. Brit. Ind. V. 298; FORBES et HEMSL. Ind. Fl. Sin. II. 422; HENRY, List Pl. Form. 82; L. DIELS, in Engl. Jahrb. XXIX. 29.

Nom. Jap. *Kidachi-komikansō*.

Nymphanthus Niruri, LOUR. Fl. Cochinch. ed-2, 545.

Herbæ v. suffrutices. Ramuli teretes leves. Folia oblonga elliptica, obtusa, v. mucronata, 3-5 mm. longa, 2-2½ mm. lata, subtus pallidiora, membranacea. Stipulæ ovatæ v. lineari-lanceolatæ, subulato acuminatæ. Flores gemini, omnes breviter pedicellati. Fl. ♂: sepala 5; stamina 3, filamentis tota longitudine in columnam connatis. Antherarum loculi horizontaliter dehiscentes. Glandulæ distinctæ, stipulæ peltatæ. Fl. ♀: calyx maris. Ovarium globosum, trisulcatum; styli brevissimi apice revoluti-bilobi. Glandulæ connatæ, 5-lobæ. Calyx fructiger 1.5 mm. longus, 1 mm. latus. Capsulæ depresso-globosæ, 2 mm. latæ, ambitu teretes, læves. Semina longitrorsum costulata, transversim minutissime striolata.

DISTRIB. in Guinea, Madagascaria, India orientali, Java, Borneo, Phillipinis, Japonia vulgaris.

HAB. in Japonia australi.

Formosa: Kachirai-sha, leg. K. MIYAKE, anno 1898; Pang-kang, Sha-gio, leg. K. MIYAKE, anno 1898.

Hondo: Prope Tokyo, anno 1880.

2. **P. urinaria** LINN. (Tab. I. C.)——LINN. Sp. Pl. ed-

2, 1393; WILLD. Sp. Pl. IV. 583; LOUR. Fl. Cochinch. 677; MIQ. Fl. Ind. Bat. I.-2, 369; MUELL. ARG. in Linnæa XXXII. 19; BENTH. Fl. HONGK. 310; MUELL. ARG. in DC. Prodr. XV.-2, 364; BENTH. Fl. Austral. 102; MIQ. Prol. 291; FRANCH. et SAVAT. Enum. Pl. Jap. I. 426; HOOK. f. Fl. Ind. V. 293; MAXIM. in Engl. Jahrb. VI. 59; FORBES et HEMSL. Ind. Fl. Sin. II. 423; HENRY, List Pl. Formos. 82; L. DIELS, in Engl. Jahrb. XXIX. 29.

P. lepidocarpus, SIEB. et ZUCC. Fl. Jap. Fam. Nat. Sect. Prim. 143; WIGHT, Ic. Pl. Ind. or. t. 1895, f. 4; MIQ. in Ann. Bot. Mus. Lugd.-Bat. III. 127.

Nom. Jap. *Komikansō*.

Suffrutices 1-2-pedales, ramulis alto-angulosis. Ramuli florigeri puberuli. Folia in ramulis disticha, anguste oblongo-elliptica, brevius acuminata, basi subacuta, margine plus minusve scabra v. ciliolato-serrulata, vulgo dense approximata, in ramulis oblique inserta, 5 mm.-1 cm. longa, 3-4 mm. lata. Stipulæ triangulari-acutæ. Fl. ♂: sepala 6; stamina 3, filamentis tota longitudine in columnam connatis, apice brevissime liberis; antheræ verticaliter birimosæ, liberæ. Glandulæ liberæ, subsessiles, peltatæ. Flores ♂ depauperato-fasciculati, in superne ramulorum dispositi, exguī vix $\frac{1}{2}$ mm. longi. Fl. ♀: calyx maris. Ovarium globosum sub-squamoso-papillosum, stylis complanatis, recurvis bifidis, ramis hamato-recurvis. Glandulæ in urceolum connatæ 10-lobæ, lobis triangulari-acutis. Flores ♀ in axillis foliorum solitarii, in inferioribus partibus ramulorum subsessiles. Capsulæ subsquamoso-verucosæ, fere sessiles, depresso-globosæ, $2\frac{1}{2}$ mm. latæ, ambitu teretes. Calyx fructiger apertus vix 1.5 mm. diametro æquans. Semina transversim costulata.

DISTRIB: In insula Ceylonia, Java, India orient., China, Japonia.

HAB. in Japonia australi medianave.

Formosa : Tong-si-kak, leg. K. MIYAKE, anno 1898 ; Sin-tiam-koe, Kutsu-shaku, leg. K. MIYAKE, anno 1898 ; Kelung, Taipea, leg. T. MAKINO, et C. OWATARI, anno 1896 ; Pachina, leg. T. NIINAMI, anno 1896.

Liu-kiu : Naha.

Hondo : Prov. Tōtōmi, in tractu Iwata, leg. K. HISAMATSU ; prope Tokyo, Hort. Bot. ; Prov. Suwau, in tractu Yoshiki, leg. G. NIKAI, anno 1901.

3. **P. simplex** RETZ. (Tab. I. D.)——WILLD. Sp. Pl. IV. 573 ; ROXB. Fl. Ind. III. 654 ; MUELL. ARG. in DC. Prodr. XV.-2, 391 ; HOOK. f. Fl. Brit. Ind. V. 295 ; BENTH. Fl. Austral. VI. 111 ; SEEMAN, Fl. Vitiensis, 220 ; FORBES et HEMSL. Ind. Fl. Sin. II. 423 ; HENRY, List. Pl. Formos. 82 ; L. DIELS, in Engl. Jahrb. XXIX. 427.

P. simplex γ *chinensis* MUELL. ARG. in Linnæa XXXII. 33.

P. anceps VAHL ; FRANCH. Pl. David. 266.

Nom. Jap. *Shima-komikansō*.

Herbæ v. suffrutices semipedales, caulibus simplicibus v. parce ramosis e caudice vulgo numerosis erectis v. adscendentibus tota v. fere tota longitudine folii-florigeris. Folia disticha, glabra, breviter petiolata, integra, penninervia, bistipitata, lineari-lanceolata utrinque obtusa v. apice acuta, 8–10 mm. longa, 3–4 mm. lata, petiolis $\frac{1}{2}$ –1 $\frac{1}{2}$ mm. longis. Stipulæ triangulari-ovatae, acutæ. Fl. ♂ : sepala 6 ; stamina 3, filamenta oblique inserta, apice recurva, basi leviter connata. Rimæ antherarum extrorsæ, inclinatione connectivorum horizontales. Glandulæ 6, liberæ, orbiculares, sessiles. Pedicelli ♂ gemini v. terni $\frac{1}{2}$ –1 mm. longi. Fl. ♀ : calyx maris. Ovarium papillosum depresso-globosum ; styli 2-fidi ; stylorum rami graciles, divergentes, ovario adpressi. Glandulæ in urceolum crenato-lobatum, undulatum, connatæ. Pedicelli longiores, 1–2 mm. longi. Capsulæ leves profunde trisulcatæ. Semina secus lineas longitrorsas regulare puncticulato-verruculosa.

DISTRIB: In India orient., Java, Borneo, Celebes, Philippinis, insulis Marianis, Formosa.

HAB. Formosa: Takao, leg. K. MIYAKE, anno 1898.

4. **P. Matsumuræ** sp. nov.——(Tab. I. E.)

Nom. Jap. *Hime-mikansō*.

Herbæ, caulibus simplicibus v. pauci ramosis. Rami florigeri ancepites, subulato-compressi. Folia disticha, 8–10 mm. longa, 4–5 mm. lata, glabra, integra, bistipitata, ovato-lanceolata, v. lineari-lanceolata, acuta, basi obtusa, subtus pallidiora, petiolis $\frac{1}{2}$ – $1\frac{1}{2}$ mm. longis. Stipulæ basi retorsæ sagittatæ, integræ, lanceo-acuminatæ. Fl. ♂: sepala 4; stamina 2, filamentis fere connatis, superne breviter liberis. Rimæ antherarum inclinatione connectorum horizontales. Glandulæ 4, liberæ, obconicæ, sessiles. Pedicelli 1–2 mm. longi, tenues. Fl. ♀: sepala 6; ovarium globosum, leve; styli patentes apice 2-lobi, lobis divergentibus, non ovario adpressis. Glandulæ liberæ, 6, subcylindricæ. Pedicelli ♀ 1–2 mm. longi, acute transversimque 3-angulosi, superne valide incrassati. Capsulæ depresso-globosæ, glabræ, 2 mm. latæ, 1 mm. longæ, leviter papillose. Semina secus lineas longitrorsas sparse irregulariterque reticulata.

A *P. simplici* differt in floribus ♂, staminibus 2, sepalis 4, glandulis liberis, stylis non ovario adpressis.

HAB. In Japonia australi vulgaris.

Prope Tokyo, anno 1880; Horinouchi, anno 1881. Prov. Iwashiro, in tractu Aidsu, Yumoto, anno 1819. Prov. Suwau, in tractu Yoshiki, leg. G. NIKAI, anno 1984; Insula Tsushima: prope Izugahara, Shinimi, leg. Y. YABE, anno 1901.

5. **P. liukiensis** MATSUMURA.——(Tab. I. E.)

Nom. Jap. *Hana-komikanboku*.

Frutices divaricati, ramis apice caulium multis, glabris,

gracilibus. Ramuli filiformes, teretes v. superne leviter compressi. Folia falcato-recurva, oblique ovata v. oblonga, 5–12 mm. longa, 3–5 mm. lata, majusculè mucronata v. obtusa, subtus glauca, penninervia, tenuiter membranacea, stipulis triangulari-ovatis, subulato-acuminatis. Pedicelli filiformes, in pulvinulis axillares. Sepala utriusque sexus oblongo-ovata, omnia denticulata. Fl. ♂ : sepala 4, 5 mm. longa v. breviora. Stamina 2 ; filamentis brevissimis, circa ovarii rudimentum inserta. Antheræ horizontaliter aperientes. Ovarii rudimentum brevissimum. Disci glandulæ in urceolum connatæ, 4-lobæ. Fl. ♀ : sepala 6. Discus integer v. margine repandus. Ovarium globosum leve, stylis divaricatis, bipartitis oriuntur gracilibus. Pedicelli fl. ♀ 5–7 mm. subæquantes, filiformes. Capsulæ depresso-globosæ, 4 mm. diametro æquantes. Semina lævia.

A *P. leptocladote* BENTH. differt ovarii rudimento evoluto, seminibus lævibus.

HAB. Liukiu : Onnah, leg. J. MATSUMURA, anno 1897.

6. ***P. flexuosus*** MUELL. ARG. (Tab. I. G.)——MUELL. ARG. in DC. Prodr. XV.–2, 324 ; FORBES et HEMSL. Ind. Fl. Sin. II. 421 ; L. DIELS, in Engl. Jahrb. XXIX. 427.

Cicca flexuosa SIEB. et ZUCC. Fl. Jap. Fam. Nat. Sect. Prim. 143.

Glochidion flexuosum FRANCH. et SAVAT. Enum. Pl. Jap. I. 426.

Nom. Jap. *Kobannoki*.

Frutex fasciculatim ramosus, ramis flexuosis, ramulis subfasciculatis compressis. Ramuli floriferi tenues, 10–15 cm. longi. Pulvinuli, e quibus oriuntur ramuli floriferi, densissime inferne coriaceo superne membranaceo-squamato-perulati. Folia ovata v.

oblongo-ovata, acutiuscula, basi brevissime inæqualiterque acuta, membranacea, olivaceo-fuscidula, densissime reticulato-venosa, 1–4 cm. longa, 7–25 mm. lata, petiolis 1–2 mm. longis, stipulis angustis, spathulato-ovatis, persistentibus, 2–2½ mm. longis, scariosis, fuscis, superne fimbriatis. Flores 5–6 fasciculati, uni ♀ mixti. Sepala 4, æqualia, imbricata, 1.5 mm. longa, coriacea. Fl. ♂ : sepala orbiculari-ovata, margine inflexa. Stamina 2, libera, filamentis validis; antheræ distinctæ verticaliter birimosæ. Glandulæ 4, liberæ, truncatæ, interdum leviter connatæ. Pedicelli fl. ♂ capillacei, 3–5 mm. longi, basi articulati. Fl. ♀ : sepala oblongo-spathulata, intus nitida. Ovarium oblongo-ovoideum, glabrum; styli 3, liberi indivisi, superne revoluti. Sepala oblongo-elliptica, decidua, omnia rotundato-obtusa. Glandulæ in urceolum connatæ, margine 4-lobatæ, lobis cum sepalis alternis. Pedicelli ♀ fl. masculis breviores, 5–3 mm. longi, ad basin calycis crassati. Bacca spuria sicca, depresso-globosa, 4 mm. longa, 6 mm. lata. Semina trigona dorso leviter alveolato-reticulata. Embryo complanatus ad dorsum seminum affixus, recurvus, cotyledonibus spathulato-complanatis.

DISTRIB.: in Japonia australi.

HAB. Kiushu: Prov. Buzen, in monte Iwatake; prov. Hiuga, in monte Kirishima, anno 1882. In insula Oshima, leg. S. MATSUDA, anno 1896.

Shikoku: Prov. Tosa, in monte Tsuetate; in tractu Sagawa, leg. T. MAKINO, anno 1887; prov. Iyo, in monte Wariishi; prov. Awa, in Nishu-mura, anno 1888.

Hondō: Prov. Nagato, in tractu Otsu, leg. G. NIKAI, anno 1902; Prov. Kii, in monte Kōya, anno 1883. Tokyo Hort. Bot. cult.

7. **P. reticulatus** POIR.; MUELL. ARG. in Linnæa XXXII. 12 et in DC. Prodr. XV.–2, 344; BENTH. Fl. Austral. VI. 101; HEMSL. in Vog. Challenger, Bot. I.–3, 187; Hook. f. Fl. Brit. Ind. V. 288; FORBES et HEMEL. Ind. Fl. Sin. II. 422; HENRY, Lis. Pl. Formos. 82.

Cicca microcarpa BENTH. Fl. Hongk. 312.

Phyllanthus microcarpus MUELL. ARG. in Linnæa, XXXII. 51 et in DC. Prodr. XV.—2, 343 ; HANCE, in Journ. Linn. Soc. XIII. 121.

Kirganelia sinensis, BAILL. " Etude Gén. Euphorb. 614."

Phyllanthus sinensis MUELL. ARG. in Linnæa, XXXII. 12. Nom. Jap. *Shima-kobannoki*.

Frutices. Rami graciles, ramulosi. Folia disticha, 3 cm. longa, 2 cm. lata, ovata, utrinque obtusa v. emarginata. Petioli 2–3 mm. longi. Stipulæ longæ, lanceolatæ, crassiusculæ. Flores ad axillas glomerati, articulato-decui, ♂ 5–6 glomerati ♀ uni mixti, longe pedicellati. Bractæ membranacæ. Fl. ♂ : sepala 5, imbricata, crassiuscula, ovata basi leviter angustata, intus nitida, extus glabra vel leviter pubescentia. Stamina 5, duo interiora connata, longiora, tres exteriora libera, filamentis brevissimis, antheris oblongo-ovatis apiculatis. Glandulæ cum staminibus alternæ. Fl. ♀ : sepala 2–5, incrassata. Ovarium globosum glabrum, 7–8-loculare ; ovula in loculis gemina, superposita, stylis stigmatitis. Drupa. Semina triangulari-ovata, sicco-rugosa ; embryo rectus, cotyledonibus complanatis.

DISTRIB.: in Asia tropica et Africa, vulgaris.

HAB. Formosa : Tai-tong-thian, Pi-lam et Tai-lam-thian, leg. K. MIYAKE, anno 1899.

8. **P.** (Sect. Embrica.) **Niinamii** sp. nov.

Nom. Jap. *Shima-ammoroku*.

Arbores? ramosæ, ramulis gracilibus, tomentosis. Folia in ramulis disticha, oblongo-elliptica, 12–18 mm. longa, 5–8 mm. lata, margine integerrima recurva, apice rotundata, glanduloso-apiculata, basi rotundato-cordata, subtus glabra, petiolis brevissimis

$\frac{1}{2}$ mm. longis, stipulis rufis, triangularibus, crassiusculis, margine laciniatis, minimis, 1 mm. longis. Flores numerosi, in axillis foliorum inferiorum parvorum siti. Fl. ♂ : sepalis 6, spathulatis, membranaceis, $2\frac{1}{2}$ mm. longis, 1 mm. latis ; glandulis 0 ; staminibus 3, filamentis tota longitudine in columnam 1 mm. longam connatis, antheris erectis, extrorsis ; pedicellis geminis v. ternis, gracilibus, 4 mm. longis. Fl. ♀ : sepalis 6, spathulatis, crassiusculis, majoribus, 3 mm. longis, $1\frac{1}{2}$ mm. latis, glandulis in urceolum crenato-dentatum connatis ; ovario globoso-ovoideo, stylis basi in columnam ovarium subæquantem connatis, 2-fidis, ramis gracilibus, 3 mm. longis, recurvis ; pedicellis brevissimis, $\frac{1}{2}$ mm. longis, solitariis. Fructus ignotus.

A. P. Embrica L, foliis oblongo-ellipticis, stylis 2-fidis, gracilibus, longioribus, facile distincta. Ceteris partibus vero utraque species persimilis.

HAB. Formosa : Shokwa, leg. T. NIINAMI, anno 1902 (Aug. fl.)

4. Glochidion FORST.

ENDL. Gen. Pl. 1121 ; PAX, in Nat. Pfl. Fam. III.-5, 23.

Flores monoici, apetali. Discus 0. Fl. ♂ : sepala 6, distincta, imbricata plus minusve 2-seriata, omnia similia v. exteriora breviora. Stamina in centro floris 3-6, filamentis connatis brevissima, antheris erectis in columna centrali sessilibus, loculis distinctis parallelis longitudinaliter dehiscentibus, connectivis prominenter apiculatis. Ovarii rudimentum 0. Fl. ♀ : calyx rigidior, brevis, incrassatus. Ovarium subglobosum, stylis brevissimis ; ovarium 3-

8-loculare; ovula in loculis gemina. Capsula sicca, demum in cocos 2-valves dissiliens. Semina ecarunculata, testa crustacea; albumen carnosum; embryo leviter incurvus, cotyledonibus planis. Frutices. Folia coriacea, integerrima, alterna, sæpius disticha. Flores parvi, axillares, ♂ pedicellati, ♀ in eadem axilla glomerati, subsessiles.

Conspectus Glochidionis Specierum.

Stamina 6-4.

Folia lanceolata; ovarium 5-4-loculare.....1. *G. lanceolatum*.

Folia elliptica; ovarium 6-8-loculare.

Tota glabra.....2. *G. zeylanicum*.

Tota hirsuta.3. *G. hirsutum*.

Stamina 3.

Ovarium 3-loculare.4. *G. bicolor*.

Ovarium 6-7-loculare.

Folia glabra.5. *G. obovatum*.

Folia pubescentia.6. *G. formosanum*.

1. ***G. lanceolatum***. sp. nov. (Tab. II. C.)

Nom. Jap. *Kiirun-kankonoki*.

Rami teretes, omnino glaberrimi, foliosi. Folia oblongo-ovata, v.-lanceolata, obtuse acuminata, basi acuta, inæquilateralia, utrinque 7-8-costata, 5-6 cm. longa, 2-3 cm. lata, petiolis 4 mm. longis, glabra, supra pallidiora, subtus fusco-virida, stipulis crassiusculis triangulari-acutis. Flores axillares, superne ♀, inferne ♂. Inflorescentia breviter pedunculati, pedunculis 8 mm. longis. Fl. ♂: sepala ovata, 2.5 mm. longa. Stamina sæpissime 4, rarius 5 v. 6. Rudimentum parvissimum ovarii in centro staminum præditum. Flores ♂ fasciculati, breviter pedicellati, pedicellis 4-5 mm. longis. Fl. ♀: sepala rotundato-ovata v. triangulari-ovata, 1.5 mm. longa. Ovarium globosum, 2 mm. longum. Stylorum

columna hemispherica, leviter 8–10–sulcata. Ovarium 4–5–loculare, rarius 6–loculare. Capsula depresso-globosa, leviter 8–sulcata.

A *G. cacumino* differt pedunculis pedicellisque florum ♂ longioribus.

HAB. Formosa : Kelung, leg. T. MAKINO et C. OWATARI, anno 1896.

2. ***G. zeylanicum*** A. JUSS.; MUELL. ARG. in Linnæa, XXXII. 60 et in DC. Prodr. XV.–2, 281 ; Hook. f. Fl. Brit. Ind. V. 311.

Nom. Jap. *Kakibano-kankonoki*.

Rami grabri, foliosi. Folia oblongo-ovata, acuta v. obtusa, basi obtusa, glabra, v. nitida, supra pallidiora, subtus fusca. Stipulæ minutæ, triangulari-ovatæ, acuminatæ, rigidæ, arete recurvæ, persistentes. Petioli 6 mm. longi. Inflorescentiæ pedunculatæ ; pedunculi 15 mm. longi, spatio circ. 6–7 mm. longo ab axilla remoti. Flores utriusque sexus in quaqu inflorescentia mixti, ♂ longius, ♀ brevius pedicellati. Fl. ♂ : sepala oblongo-ovata, 3½ mm. longa, levia. Stamina sæpissime 5. Fl. ♀ : glomerato-fasciculati. Sepala ovata, acuta, levia, 2 mm. longa, interiora angustiora. Ovarium globosum, glabrum, 8–9–loculare ; columna stylaris conica, truncata, apice 5–6–fida. Capsula depresso-globosa, circ. 18–sulcata, ambitu teres, 7 mm. lata, 4 mm. longa.

DISTRIB. In insula Ceylonia, Banca juxta Sumatra, Borneo, peninsula Indiæ orientalis, Formosa, Liu-kiu.

HAB. Formosa : Taipea, leg. T. MAKINO et K. HONDA, anno 1896. Kelung, leg. C. OWATARI, anno 1896. In Tai-tong-thian, Ka-leng-oan, leg. K. MIYAKE, anno 1899.

Liu-kiu : Yontanzan, leg. J. MATSUMURA, anno 1897.

3. ***G. hirsutum*** MUELL. ARG. (Tab. II. D.)——MUELL. ARG. in Linnæa, XXXII. 61 ; Hook. f. Fl. Brit. Ind. V. 311.

Bradleya hirsuta ROXB. Fl. Ind. III. 699. "Baill. Etude Gen. Euphorb. 638."

Phyllanthus hirsutus MUELL. ARG. in DC. Prodr. XV.-2, 283.
Nom. Jap. *Obano-kekankonoki*.

Ramuli crassiusculi oligophylli, dense puberuli, apice fulvo-tomentelli. Petioli 3 mm. longi. Stipulae lineari-subulatae, arcuato-reflexae, 3 mm. longae. Folia oblongo-ovata, 10–15 cm. longa, 6–8 cm. lata, obtusa, basi oblique truncato-obtusa, latere interiore obtusa v. leviter retusa, exteriore saepius acuta, supra paucius subtus densius pubescentia. Inflorescentiae paulo supra-axillares, cum ramulo basi connatae, et 5–6 mm. supra axillam folii quasi insertae, pedunculatae. Fl. ♂ fasciculati, pedicellis 13 mm. longis. Sepala 2 mm. longa, late elliptica, cum pedicello tenui-vel griseo-pubescentia. Stamina 6. Fl. ♀ : calyx 2.5 mm. longus, 6-lobatus, lobis crassis, acutis; ovarium globosum, cum pedicello omnino pubescens. Pedicelli 3 mm. longi. Capsula depresso-globosa, 8½ mm. diametro aequans, 7 mm. longa, pubescens, non sulcata, 12-sperma, v. abortu 6-sperma. Semina valde compressa, 4 mm. longa, 2½ mm. lata, 1 mm. crassitudine aequantia.

DISTRIB. In insula Penang, Indiae orient. et Formosa.

HAB. Formosa : Taipea, leg. K. HONDA, anno 1896; Po-li-sia, Tsui-sia, leg. K. MIYAKE, anno 1898.

4. **G. bicolor** (MUELL. ARG.) (Tab. II. E.)

G. acuminatum MUELL. ARG. in Linnæa, XXXII. 68.

Phyllanthus bicolor MUELL. ARG. in DC. Prodr. XV.-2, 311.
Nom. Jap. *Uraziro-kankonoki*.

Ramuli apice pallide fulvo-sericeo-pubescentes. Petioli 2–3 mm. longi. Folia 4–8 cm. longa, 1.5–3 cm. lata, lanceolata, utrinque acuta, leviter inaequilateralia, supra in costis pubescentia, caeterum glabra, subtus plus minusve argenteo-pallida vel albicantia,

brevissime pubescentia. Flores ♂ fasciculati, pedicellis pubescentibus $4\frac{1}{2}$ mm. longis. Sepala 2 mm. longa, extus pubescentia. Stamina 3. Flores ♀ primum subglomerati. Sepala oblongo-elliptica, acuta, $\frac{1}{2}$ –1 mm. longa, interiora angustiora, parviora; ovarium 3-loculare, globosum sericeum, cum stylis $1\frac{1}{2}$ mm. longum; columna stylaris cylindrica, superne paulo latiora, breviter 3-fida, ovarium longitudine ter v. quater æquans. Capsula parva, depressa, profunde sulcata, basi et apice umbilicato-depressa, 4 mm. longa, 7 mm. lata. Semina ovoidea, 3 mm. lata, $3\frac{1}{2}$ mm. longa. Fasciculi fl. ♂ in axillas inferiores, fl. ♀ primum glomerati, in axillas superiores dispositi.

DISTRIB.: In Nepalia, Sikkim, Bengalia orientali, Formosa, et Liu-kiu.

HAB. Formosa: Pak-kang-khoe, Tsuisia, Po-li-sia, leg. K. MIYAKE, anno 1898.

Liu-kiu: Leg. J. MATSUMURA, anno 1897; in Insula Oshima, Nase, leg. T. UCHIYAMA, anno 1900.

5. **G. obovatum** SIEB. et ZUCC. (Tab. II. F.)——SIEB. et ZUCC. Fl. Jap. Fam. Nat. Sect. Prim. 143; MUELL. ARG. in Linnæa, XXXII. 67; MIQ. Prol. 292; FORBES et HEMSL. Ind. Fl. Sin. II. 425.

Phyllanthus obovatus MUELL. ARG. in DC. Prodr. XV.-2, 307.

Nom. Jap. *Kankonoki*.

Ramuli pauce et tenuiter pubescentes. Petioli $1\frac{1}{2}$ –2 mm. longi. Stipulæ minimæ, ovatæ, subacutæ. Folia 3–6 cm. longa, 2–3 cm. lata, obovata, oblongo-ovata, vel obovato-lanceolata, obtusa, rotundata v. breviter acuminata, basin versus sensim cuneato-angustata, glabra. Flores ♂ pedicellati, pedicellis evolutis, 10 mm. longis. Calyx 2 mm. longus; sepala oblongo-ovata, interiora angustiora; stamina 3. Flores ♀ longe pedicellati; pedicelli 8–9 mm. longi. Calyx 6-lobatus, lobis crassiusculis, acutis, interioribus angustioribus. Columna stylaris cylindrico-obovoidea, apice obtusa,

6-fida, sursum latior, deorsum angustior, ovarium longitudine bis æquans, crassa. Ovarium 6-loculare, glabrum v. leviter pubescens, depresso-globosum. Calyx $1\frac{1}{2}$ mm. longus. Capsula depresso-globosa, profunde sulcata, $3\frac{1}{2}$ mm. longa, 6 mm. diametro æquans. Semina.....

DISTRIB. in China, Japonia australi.

HAB. Formosa : Tantsui, Kelung, leg. T. MAKINO, anno 1896 ; Takao, leg. C. OWATARI, anno 1896 ; Hok-ki-tsng, leg. K. MIYAKE, anno 1897 ; Kachilai et Ka-chin-lo, leg. K. MIYAKE, anno 1898.

Liu-kiu : in insula Oshima, leg. T. UCHIYAMA, anno 1900.

Kiushiu : prov. Higo, prov. Tikuzen, in tractu Kasuya, leg. K. NAGANO ; prov. Hiuga, in Mimitsu ; prov. Hizen, in monte Onsen-gatake, anno 1892.

Hondo : prov. Suwau, in tractu Yoshiki, leg. G. NIKAI, anno 1899 ; prov. Kii in Minamichi, anno 1883. Tokyo Hort. Bot., cult.

6. **G. formosanum** sp. nov. (Tab. II. G.)

Nom. Jap. *Ke-kankonoki*.

Plantæ omnino pubescentes. Rami teretes, oligophylli. Folia oblongo-ovata v. oblongo-elliptica, apice obtusa v. acuta, basi oblique truncato-obtusa, latere interiore obtusa, exteriori acuta, supra pauce, subtus densiuscule pubescentia, 7–8 cm. longa, 3–4 cm. lata, petiolis 4 mm. longis. Flores ♂ fasciculati ; longe pedicellati, pedicellis 8 mm. longis ; sepalis 6, interioribus parvioribus, ovatis acutis, intus et extus brevissime pubescentibus, 3 mm. longis. Stamina 3, rarissime 4. Flores ♀ breviter pedicellati, pedicellis 2.5 mm. longis ; calyx 1 mm. longus, 6-lobatus, lobis brevissimis ; ovarium ovoideum cum stylis 2 mm. longum ; columna stylaris depresso-globosa, leviter 7–8-sulcata, basi constricta, ovario brevior ; ovarium 6–7-loculare. Capsula depresso-globosa, 10–12-sulcata, ambitu teres.

HAB. Formosa : Tai-tong-thian, Pi-lam, leg. K. MIYAKE, anno 1899.

5. *Breynia* FORST.

ENDL. Gen. Pl. 1120; MUELL. ARG. in DC. Prodr. XV.—

2, 438; BAILL. Hist. d. Pl. V. 254; BENTH. et HOOK.

Gen. Pl. III. 276; PAX, in Nat. Pfl. Fam. III.—5, 24.

Flores monoici, apetalii. Discus 0. Fl. ♂: calyx breviter turbina-
tus, supra planus, lobis v. dentibus inflexis fere clausus. Stamina
3, filamentis in columnam centralem connatis; antheræ ad apicem
columnæ sessiles adnatæ, loculis parallelis longitudinaliter dehiscenti-
bus. Rudimentum ovarii 0. Fl. ♀: calyx campanulatus, fructiger
interdem auctus, explanatus, lobis brevibus nunc ad dentes minutos
reductis. Ovarium sessile v. breviter stipitatum, 3-loculare, superne
carnosum; styli indivisi v. apice 2-fidi; ovula in loculis gemina.
Bacca globosa, indehiscens. Semina triquetra, dorso rotundata,
testa crustacea, ventre duplicata inter laminas cava; albumen haud
copiosum, circa cavum incurvum; embryo curvus, cotyledonibus
latiusculis planis.—Frutices. Folia alterna, petiolata, sæpius dis-
ticha, siccitate nigricantia. Flores axillares, parvi, pedicellati,
fasciculati, fasciculo rarius in racemum brevissimum excurrente.

Conspectus Breyniarum Specierum.

Calyx fructiger accrescens, dilatatus.

Ovarium inclusum; bacca apice producta.1. *B. accrescens* form. *α*.

Ovarium exsertum; bacca apice depressa.2. *B. accrescens* form. *β*.

Calyx fructiger vix accrescens, campanulatus.3. *B. rhamnoides*.

Calyx fructiger non accrescens.

Stipulæ breves triangulares; calyx ♂ turbينات, staminibus exsertis.

.....4. *B. stipitata* var. *formosana* form. *α*.

Stipulæ subulato-acuminatæ; calyx ♂ subglobosus, staminibus inclusis.

.....5. *B. stipitata* var. *formosana* form. *β*.

1. **B. accrescens** sp. nov. form. *a.* (Tab. I. H.)

Nom. Jap. *Hime-kobannoki*.

Rami graciles, flexuosi. Folia disticha, membranacea, breviter petiolata, ovata, apice rotundato-obtusa, basi acuta, 2 cm. longa, 1.5 cm. lata, petiolis 2–3 mm. longis, stipulis minimis, subulato-lanceolatis, subtus pallidiora. Flores ♂ pedicellati, pedicellis 8 mm. longis; calyces turbinati 2 mm. longi, 1½ mm. in diametro æquantes; 2–3-fasciculati, 2–3-bracteati. Flores ♀ ad axillas solitarii, pedicellis 3 mm. longis, calycem æquantibus. Calyx turbinato-campanulatus, margine obscure 6-fractus. Ovarium ovoideum, truncatum, vertice foveolatum, inclusum. Calyces fructigeri dilatati, hemisphérico-deplanati, subintegri, leviter 2-lobati, 5 mm. diametro æquantes, pedicellis 5 mm. longis. Baccæ globosæ 4 mm. diametro æquantes, apice productæ. Semina triquetra, 3½ mm. longa, 1.5 mm. lata.

Similans *B. coronatam*, Hook. f.; sed floribus ♂ fasciculatis, foliis minimis, fascile distincta.

HAB. Formosa : Kotōshō, leg. K. MIYAKE, anno, 1899.

Nom. Formos. *Kakaridd-pariggudd*

2. **B. accrescens** sp. nov. form. *β.* (Tab. I. I.)

Fl. ♀ : calyces campanulati, 1 mm. longi, distincte 6-lobati, lobis acutis; ovarium exsertum, ovoideum, truncatum, vertice concavum, in centro stigmatibus minimis. Calyces fructigeri dilatati deplanati, margine breviter crenulati, 3½ mm. diametro æquantes. Baccæ globosæ, 5 mm. diametro æquantes, apice depressæ.

HAB. Formosa : Tamsui, leg. T. MAKINO, anno 1896.

3. **B. rhamnoides** MUELL, ARG.; (Tab. I. J.)——MUELL. ARG. in DC. Prodr. XV.-2, 440; Hook. f. Fl. Brt. Ind. V. 330; FORBES et HEMSL. Ind. Fl. Sin. II. 428; L. DIELS, in Engl. Jahrb. XXIX. 427.

Phyllanthus rhamnoides WILLD. Sp. Pl. IV. 580; Hook. et ARN. Bot. Beech. Vog. 270.

P. vitis-idaea ROXB. Fl. Ind. III. 665.

Melanthesa rhamnoides WIGHT, Ic. Fl. Ind. or. t. 1898; MIQ. Fl. Ind. Bat. I.-2, 370.

Nom. Jap. *Ōshima-kobannoki*.

Frutices glaberrimi. Folia brevissime petiolata, petiolis 3 mm. longis, membranacea, ovata vel orbiculari-obovata, rotundato-obtusa, 3 cm. longa, 2½ cm. lata. Flores ♂ 3-4, fasciculati, pedicellis 7 mm. longis; calyces turbinati v. subcampanulati, margine obscure lobati, 2½ mm. longi, 1½ mm. diametro aequantes. Flores ♀ solitarii; calyces 2 mm. longi, hemispherico-campanulati, 6-dentati; ovarium subglobosum, apice truncatum, concavum, vix exsertum. Pedicelli 4 mm. longi. Baccae globosae, vertice obsolete disciformi-tumidae, 3½ mm. longae, 6 mm. latae, breviter stipitatae. Calyx fructiger vix accrescens. Semina triquetra, 3½ mm. longa, 2½ mm. lata.

DISTRIB. In tropica Asia, vulgaris.

HAB. Formosa: Ang-thau-su, leg. K. MIYAKE, anno 1899.

Liu-kiu: Naha; Oshima, leg. T. UCHIYAMA, anno 1900.

4. **B. stipitata** MUELL. ARG. var. **formosana** var. nov. form. *a.* (Tab. II. A.)

Nom. Jap. *Daiwan-kobannoki*.

Rami graciles. Folia coriacea v. membranacea; stipulae triangulari-ovatae, subulato-acuminatae. Petioli 3 mm. longi. Folia 1½-2½ cm. longa, 1.5-1 cm. lata, oblongo-ovata, apice obtusa, basi inaequilaterialia, acuta, supra olivaceo-viridia, subtus pallidiora. Flores ♂ 2-3, fasciculati, pedicellis 6 mm. longis.

Calyces turbinati, 6-lobati, $1\frac{1}{2}$ mm. longi. Flores ♀ ad axillas solitarii, breviter pedicellati. Calyx 2 mm. longus, pedicellum æquans, obconicus acute breviterque 6-lobatus, sub fructu non accrescens. Ovarium turbinato-obconicum, apice latum, concavum tumido-stigmatum. Baccæ subdepresso-ovoideæ, basi distincte in stipitem calyci urceolari subæquilongum gracilem attenuatæ, 4 mm. longæ, 6 mm. latæ. Stipes $2\frac{1}{2}$ –3 mm. longus, apice abrupte in fructum abiens. Semina.....

HAB. Formosa : Shintekku, leg. T. MAKINO, anno 1896.

5. **B. stipitata** MUELL. ARG. var. **formosana** var. nov. form. β. (Tab. II. B.)

Stipulae lineari-lanceolatae, acuminatae. Folia ovata, utrinque subacuta, supra nigra, subtus glauca. Flores ♂ : calyx subglobosus, margine 6-dentatus, staminibus inclusis. Fl. ♀ : ovarium cylindricum, truncatum, apice leviter trisulcatum.

HAB. Formosa : Taipea, anno 1896.

6. *Putranjiva* WALL.

ENDL. Gen. Pl. 287 ; MUELL. ARG. in DC. Prodr. XV.—
2, 443 ; BAILL. Hist. d. Pl. V. 249 ; BENTH. et
HOOK. Gen. Pl. III. 277 ; PAX. in Nat. Pfl. Fam.
III.—5, 27.

Flores dioici apetalii. Discus 0. Fl. ♂ : calyx tenuis, 4–6-partitus, segmentis inaequalibus, imbricatis. Stamina 2, filamentis

compressis, in centro floris basi connatis; antherae globoso-ellipsoideae, crassiusculae, utrinque obtusae, erectae, extrorsae, loculis distinctis, parallelis longitudinaliter dehiscentibus. Rudimentum ovarii 0. Fl. ♀ : calyx tenuis, 3-partitus, segmentis angustis. Ovarium oblongo-ovoideum, 3-loculare; ovula in loculis gemina. Styli longiusculi, patentes, in ramos totos carnosos papillosos expansi. Drupa oblongo-ovoidea, endocarpio duro, fere osseo, abortu 1-locularis, 1-sperma. Semina oblongo-ovoidea; testa tenuis; albumen carnosum; embryo rectus, magnus, cotyledonibus latis planis, palmatinerviis.—Arbores? Folia alterna, bistipulata, crenulato-serrulata, rigide membranacea v. coriacea, dense tenuiterque pennivenia et reticulato-venosa. Flores axillares, ♂ in racemos glomerati, brevissime pedicellati, ♀ longius pedicellati, solitarii.

1. **P. Roxburghii** WALL. (Tab. II. H.)——WIGHT, Ic. Pl. Ind. or. t. 1876; MUELL. ARG. in DC. Prodr. XV.-2, 443; BEDDOME, Fl. Sylv. Sou. Ind. t. 275; HOOK. f. Fl. Brit. Ind. V. 336; MATSUMURA, in Tokyo Bot. Mag. XII. 61.

Nageia Putranjiva, ROXB. Fl. Ind. III. 766.

Nom. Jap. *Tsugemodoki*.

Rami graciles, teretes, superne angulosi, glabrati. Ramuli acute sulcato-angulosi, obscure pubescentes. Petioli 7-10 mm. longi, firmi, supra canaliculati, pubescentes. Folia elliptica, apice obtuse acuminata, basi acuta, 3-5 cm. longa, 1-3 cm. lata, elliptica, juniores membranacea, evoluta chartacea, margine adpresso-pubescentia, denum glabrata. Fl. ♂ racemoso-spicati. Bractae multiflorae. Calyx 1-2 mm. longus; laciniae margine densius ciliato-pubescentes, dorso paucius puberulae. Antherae crassae, exsertae, 1 mm. longae, hirtellae. Fl. ♀ pedicellis 5-10 mm. longis, sub fructu circ. 12 mm. attingentibus, validiusculis.

Calyceis ♀ laciniae $1\frac{1}{2}$ –2 mm. longæ, sub fructu deciduæ, oblongo-ellipticæ, apice rotundatæ. Ovarium oblongo-cylindricum, calycem tri-quater æquans, sub-fulvo-sericeum. Drupa oblongo-ellipsoidea utrinque angustata, 20 mm. longa, 13 mm. lata, pilis densis pallidis brevissime tomentella.

DISTRIB. In peninsula Ind. orient.; Formosa et Liu-kiu.

HAB. Formosa : Ang-thau-su, leg. K. MIYAKE, anno 1899.

Liu-kiu : Ins. Okinawa, leg. J. MATSUMURA, anno 1897 ; Shuri, leg. K. MIYAKE, anno 1899 ; Ins. Miyakojima, leg. S. TANAKA, anno 1879 ; Ins. Okinawa, leg. Y. TASHIRO, anno 1897.

7. *Antidesma* LINN.

LINN. Sp. Pl. ed.-2, 1455 ; ENDL. Gen. Pl. 287 ; MUELL.

ARG. in DC. Prodr. XV.-2, 248 ; BENTH. et HOOK.

Gen. Pl. III. 284 ; PAX, in Nat. Pfl. Fam. III.-5, 30.

Flores dioici, apetalii. Fl. ♂ : calyx alte 3–4-lobatus, lobis imbricatis. Discus evolutus, glandulis staminibus alternis, concretis. Stamina 4–5, lobis calycis opposita, filamentis liberis, longis, sub anthesin calycem vulgo 2–4-plo superantibus. Antherarum loculi in alabastro extrorsum aperientes, loculi post oscillationem superne divergentes, introrsum aperti. Rudimentum ovarii 0. Fl. ♀ : calyx 5–6-partitus. Disci annulares. Ovarium 1-loculare ; styli 3, brevissimi ; ovula in loculo gemina. Drupa parva, subcarnosa, obliqua, indehiscens. Putamen osseo-coriaceum, foveolatum, carinatum. Semina abortu unica, ecarunculata ; albumen carnosum ; embryo rectus, cotyledonibus planis latis.—Frutices. Folia alterna, bistipulata, breviter petiolata, penninervia ; costae

ante marginem integrum arcuato-adscendentes, anastomosantes. Flores parvi, racemosi, racemis tenuibus, ad axillas solitariis. Bracteae parvae.

1. **A. japonica** SIEB. et ZUCC.; (Tab. II. I.)——BENTH. Fl. HONGK. 318; MUELL. ARG. in DC. Prodr. XV.-2, 258; MAXIM. in Engl. Jahrb. VI. 59; FORBES et HEMSL. Ind. Fl. Sin. II. 432; HENRY, List. Pl. Formos. 83.

Nom. Jap. *Uguyoshi* vel *yama-hihatsu*.

Ramuli tenues glabri v. pilis brevibus scabridi. Folia 4–9 cm. longa, 1–3 cm. lata, lanceolato-elliptica v. latius angustiusve lanceolata, acuminata, basi attenuata, glabra, subtus ad nervos parce pubescentia, fusco-viridia v. dein fuscidula, stipulis lineari-lanceolatis membranaceis deciduis. Petioli pubescentes, 4–8 mm. longi. Racemi omnino pubescentes. Bracteae lanceolatae, ovatae, acutae. Stamina valde exserta, filamentis validis. Calyx dilatatus, 3–4-lobatus, lobis brevissimis. Flores ♀ pedicellis gracilibus, filiformibus, horizontaliter patentibus. Calyx urceolatus, lobis brevibus. Drupa elliptica subincurva, pedicello vix duplo longior, 6 mm. longa, 5 mm. lata, sicco grosse subfoveolato-rugosa.

DISTRIB. In Hongkong, Japonia australi.

HAB. Formosa: In monte Taiton ad 300 m. alt., Rev. U. Faurie, anno 1903.

Liu-kiu: Okinawa, Yaeyama, Miyakojima, leg. Y. TASHIRO, anno 1887; Yaeyama, in monte Urabu, Yonakuni, Tamatsuku, leg. S. TANAKA, anno 1891; in monte Ubashimata, Kunchan, leg. J. MATSUMURA, anno 1897; in insula Kumesima, leg. K. KUROIWA, anno 1898; in insula Oshima, in monte Takamine, leg. T. UCHIYAMA, anno 1900.

8. *Bischoffia* BLUME.

ENDL. Gen. Pl. 1149; MUELL. ARG. in DC. Prodr. XV.-2, 478; BAILL. Hist. d. Pl. V. 227; BENTH. et Hook. Gen. Pl. III. 281; PAX, in Nat. Pfl. Fam. III.-5, 33.

Flores dioici, apetal. Discus 0. Fl. ♂ : sepala 5, imbricata, margine induplicato-cucullato-concava. Stamina 5, filamentis brevibus, circa rudimentum ovarii horizontaliter inserta, sepalis opposita; antherae magnae, loculis parallelis distinctis versus medium affixis longitudinaliter dehiscentibus. Ovarii rudimentum breve, latum. Fl. ♀ :..... Fructus subbaccatus, globosus, indehiscens, 3-locularis, mesocarpio carnoso, endocarpio pergameno. Semina ecarunculata, testis crustaceis; albumen carnosum; embryo rectus, cotyledonibus planis latis, cordato-ovatis complanatis, leviter recurvis.—Arbores. Folia alterna, 3-foliolata, foliolis longe petiolulatis, majusculis, crenatis. Racemi laterales; ♂ paniculato-ramosi, brevius pedicellati.

1. **B. javanica** BLUME; Miq. Fl. Ind. Bat. I.-2, 363; BENTH. Fl. Hongk. 316; MUELL. ARG. in DC. Prodr. XV.-2, 478; SEEMAN, Fl. Vitiensis, 221; BEDDOME, Fl. Sylv. Sou. Ind. t. 259; MAXIM. in Engl. Jahrb. VI. 59; Hook. f. Fl. Brit. Ind. V. 345; FORBES et HEMSL. Fl. Ind. Sin. II. 428; HENRY, List Pl. Formos. 83; L. DIELS, in Engl. Jahrb. XXIX. 428.

Andrachne trifoliata ROXB. Fl. Ind. III. 728.

Bischoffia trifoliata HOOK. Ic. PL. t. 844.

B. Roeperiana DECNE; "BAILL. Etude Gen. Euphorb. t. 26."

Nom. Jap. *Akagi*.

Rami teretes grabri. Folia trifoliata, foliolis petiolulatis; petiolulus terminalis reliquis longior; foliola ovata, penninervia, margine crenato-dentata, rigide membranacea, basi acuta, apice cuspidato-acuminata, 5–10 cm. longa. Petioluli laterales 5–2.5 cm. longi, terminales 5–7 cm. longi. Filamenta libera; antheræ late ovoideae, utrinque emarginatae, extrorsum aperientes. Ovarii rudimentum cylindricum, breve, vertice in discum crenulatum et planum dilatatum. Pedicelli masc. calycem semul v. bis aequantes, ad medium articulati. Pedicelli fructigeri incrassati, fructum longiuscule superantes. Fructus ovoideus, rugulosus, basi brevissime contracto-angustatus. Semina semiglobosa.

DISTRIB. India, Malaya, Polynesia, Formosa et Liu-kiu.

HAB. Formosa: Ang-thau-su, Tai-tong-thian, Pi-lam, leg. K. MIYAKE, anno 1899; Chip-chip-koe, Lim-ki-po, leg. C. OWATARI, anno 1898; Pachina, Tamsui, leg. T. MAKINO, anno 1896.

Liu-kiu: Insula Okinawa, Naha.

9. *Bridelia* WILLD.

WILLD. Sp. Pl. IV. 978; Endl. Gen. Pl. 1119; MUELL.

ARG. in DC. Prodr. XV.-2, 493; BENTH. et HOOK.

Gen. Pl. III. 267; PAX, in Nat. Pfl. Fam. III.-5, 35.

Flores monoici, petaliferi. Fl ♂: sepala 5, valvata; petala 5, brevia, squamiformia, spathulata. Discus margine subinteger. Stamina 5, filamentis in medio disco basi in columnam connatis, superne liberis patentibus; antherae obovoideae, loculis parallelis, longitudinaliter dehiscentibus. Rudimentum ovarii ad apicem

columnæ styliforme. Fl. ♀ : calycis segmenta quam ♂ angustiora. Petala maris. Discus duplex, interiore cupulato 6-lobato, ovarii basin arcte cingente. Ovarium 2-loculare. Baccæ indehiscentes, mesocarpiis carnosis, endocarpiis osseis. Semina in pyrenis abortu solitaria; albumen carnosum facie interiore late profundeque excavatum; embryo cavo albuminis parallelus, cotyledonibus latis tenuibus; radícula brevissima.—Frutices. Folia alterna, breviter petiolata, integerrima, venis primariis pinnatis, secundariis transversis, utrinque prominulis. Flores ad axillas glomerati, bracteati, ♂ numerosi, ♀ solitarii, breviter pedicellati. Bractee stipulares.

1. **B. tomentosa** BLUME; (Tab. III. A.)——Miq. Fl. Ind. Bat. I.-2, 364; BENTH. Fl. Hongk. 309; MUELL. ARG. in DC. Prodr. XV.-2, 501; BENTH. Fl. Austral. VI. 120; Hook. f. Fl. Brit. Ind. V. 271; FORBES et HEMSL. Ind. Fl. Sin. II. 420; HENRY, List. Pl. Formos. 82.

Bridelia Loureiri HOOK. et ARN. Bot. Beech. Voy. 211.

Nom. Jap. *Kankomodoki*.

Frutices ramosi, ramulis pilosis, rufescentibus, tenuibus flexilibus. Folia submembranacea, ovoidea, lanceolata, utrinque subacuta, breviter petiolata, 7-3 cm. longa, 4-1½ cm. lata, margine suberenata, costis secundariis utrinque latere 7-8, supra glabra, subtus molliter ferrugineo-puberula, petiolis 5-3 mm. longis. Flores ♂ aperientes 7 mm. diametro aequantes, sepalis triangulari-ovatis, demum patulis, intus parce hirsutis, 1½ mm. longis, 1 mm. latis; petalis angustioribus, plicato-bigibbosis, 1½ mm. longis, stipitatis. Rudimentum ovarii 2 mm. longum, apice stigmatum. Columnae staminum et antherae parce hirsutae. Discus complanatus, margine leviter sinuatus. Pedicelli ½ mm. longi. Flores ♀ : sepala et petala more ♂, sed parviora. Calyx extus parce pubes-

cens. Discus duplex, exteriore annulari, interiore cupuliformi 6-lobato. Ovarium oblongo-globosum, stylis bifidis. Baccæ 7 mm. longæ, 6 mm. latae.

Nom. Formos. *Tu-mi-shu*. (fide Henry).

DISTRIB. In Java, Indiae orient., Hongkong, Australia et Formosa.

HAB. Formosa : Hong-san, Tong-si-kak, leg. K. MIYAKE, anno 1898.

10. *Daphniphyllum* BLUME.

ENDL. Gen. Pl. 1104; Muell. Arg. XVI.-1, 1; BAILL.

Hist. d. Pl. V. 292; BENTH. et Hook. Gen. Pl. III.

282; PAX, in Nat. Pfl. Fam. III.-5, 36.

Flores dioici, apetalî. Fl. ♂: calyx obsoletus v. evolutus, segmentis 5-8, parvis. Stamina 5-10, filamentis brevibus, liberis, e basi radiato-divergente adscendentibus; antherae magnæ, erectæ, tetragonæ, a dorso compressæ, loculis parallelis, adnatis, lateraliter 2-valvatim dehiscentibus. Rudimentum ovarii 0. Pedicelli mox articulato-decidui. Disci glandulae 5 v. 0. Fl. ♀: calyx maris. Ovarium vix perfecte 2-loculare; styli distincti, crassiusculi, recurvo-patentes, indivisi; ovula in loculis gemina. Drupa oliviformis, indehiscens, abortu 1-sperma, mesocarpio crassiusculi, endocarpio rigide chartaceo, intus albo, sericeo-fibroso. Semina ecarunculata, testis membranaceis; albumen crasso-carnosum, oleagineum, olivaceo-nigrescens; embryo apicalis, albumine circ. sexies brevior, cotyledonibus semicylindricis, latitudine radiculam æquantibus. Frutices v. arbores glabrae. Rami teretes densiuscule foliosi, glabri. Folia alterna, petiolata, integerrima, coriacea, saepe angusta, penninervia, reticulato-venosa, subtus glaucescentia.

Racemi utriusque sexus axillares, breves, laxiusculi, bracteis minutis. Flores pedicellati, secus rhachin sparsi.

Conspectus Daphniphylli Specierum.

Calyx obsoletus.	1. <i>D. macropodum.</i>
Calyx evolutus.	
Stamina 8.	
Folia elliptica.....	2. <i>D. glaucescens.</i>
Folia oblongo-lanceolata, acuminata.	3. <i>D. glaucescens</i> var. <i>Oldhami.</i>
Stamina 5.....	4. <i>D. himalayense.</i>

1. **D. macropodum** MIQ.; (Tab. II. J.)——MIQ. in Ann. Mus. Bot. Lugd.-Bat. III. 129 et in Prol. 393; MUELL. ARG. in DC. Prodr. XVI.—1, 5; FORBES et HEMSLEY. Ind. Fl. Sin. 429; L. DIELS, in Engl. Jahrb. XXIX. 428; SHIRASAWA, Nippon shin-rin-jumokuzusetz, vol. 1, t. 54.

Nom. Jap. *Yuzuriha*.

Ramuli validi, superne angulati et foliosi. Folia coriacea 9–18 cm. longa, 3–7 cm. lata, e basi acute elliptico-oblonga, v. sublanceolata, apice abrupte brevissime acuteque duro-apiculata, glabra, subtus subglauca, margine extremo leviter recurva, costulae utrinque 12–15, erecto-patulae, tenerae. Petioli vulgo 3–5 cm. longi, canaliculati. Fl. ♂ : calyx obsoletus. Stamina 8–10; antherae rhomboideae, 3 mm. longae. Fl. ♂ aperientes 7 mm. diametro aequantes. Pedicelli 10 mm. longi. Fl. ♀ : calyx obsoletus; staminodia 10, crasso-carnosa, digitaliformia, 1 mm. longa. Ovarium globosum, glabrum, stylis 2, divaricato-adpressis, lanceolatis, intus canaliculatis, leviter papillois. Fructus oblongo-globosus, siccus nigricans; endocarpium firmum, foveolatum.

DISTRIB. in China australi, Japonia.

HAB. Hondo : prope Tokyo, Insula Hachijojima, anno 1881; prov. Kii, anno

1883. Prov. Kaga, anno 1881. Insula Sado, anno 1886. Insula Kōzushima, anno 1887. Prov. Shinano, anno 1884. Prov. Iwashiro, anno 1879. Prov. Izu, insula Oshima, in monte Mihara, anno 1887. Prov. Suwō, in tractu Yoshiki, leg. G. NIKAI, anno 1893.

2. **D. glaucescens** BLUME; (Tab. II. K.)——MIQ. Fl. Ind. Bat. I.-2. 431; BEDDOME, Fl. Sylv. Sou. Ind. t. 288; MUELL. ARG. in DC. Prodr. XVI.-1, 3; FRANCH. et SAVAT. Enum. Pl. Jap. I. 427 et II. 488; HANCE, in Journ. Linn. Soc. XIII. 120; MAXIM. in Engl. Jahrb. VI. 59; HOOK. f. Fl. Brit. Ind. V. 353; FORBES et HEMSL. Ind. Fl. Sin. II. 429; HENRY, List Pl. Formos. 83; L. DIELS, in Engl. Jahrb. XXIX. 428.

Gomphia neilgherrensis WIGHT, Ic. Pl. Ind. or. t. 1878-1879.

Daphniphyllum Roxburghii BAILL. "Etud. Gen. Euphorb. 565"; BENTH. Fl. Hongk. 316; MIQ. in Ann. Mus. Bot. Lugd-Bat. III. 129.

Nom. Jap. *Hime-yuzuriha*.

Frutices. Folia oblongo-obovata, v. obovato-lanceolata, apice nunc rotundato-obtusa nunc acuta, basi subacuta, 8-10 cm. longa, 3-4 cm. lata, margine integro-recurva, sæpius apice sinuato-serrata, subtus glaucescentia. Flores ♂: calyx aperiens planus, quadratus, laciniis 4 acutis. Stamina 8; antheræ introrsæ, oblongo-globosæ, a dorso compressæ, 2 mm. longæ, filamentis brevioribus, plus minusve apiculatæ. Flores ♀: calyx tenuis, laciniis 6-8, acutis, membranaceis; ovarium oblongo-ovoideum, stylis basi connatis, recurvis. Fructus obovoideo-ellipsoideus, 9 mm. longus.

DISTRIB.: In India orient., Ceylonia, Japonia.

HAB. Formosa: Su-hun, leg. C. OWATARI, anno 1897. Tsui-sia, leg. K. MIYAKE, anno 1898.

Liu-kiu: Okinawa, leg. Y. TASHIRO, anno 1887. Kumeshima, leg. H. KUROIWA, anno 1898.

Hondō : Niijima, anno 1887 ; Hachijojima, anno 1887. Prov. Idzu, anno 1883.
 Prov. Setsu, anno 1880. Prov. Kii, anno 1873. Prov. Nagato, leg. G.
 NIKAI, anno 1900.

3. **D. glaucescens** BL. var. **Oldhami** HEMSL. in Forbes
 et Hemsl. Ind. Fl. Sin. II. 429.

Nom. Jap. *Nagabano-himeyuzuriha*.

Folia 8–16 cm. longa, 1.5–3 cm. lata, acutissime acuminata,
 subtus pallidiora.

HAB. Formosa : Lok-ko-tsug, Tsui-sia, leg. K. MIYAKE, anno 1898 ; Po-li-
 sia, leg. K. MIYAKE, anno 1898.

4. **D. himalayense** MUELL. ARG. (Tab. II. L.)——
 MUELL. ARG. in DC. XVI.-1, 4 ; Hook. f. Fl. Brit. Ind. V. 354.

D. Benthami “BAILL. Etude Gen. Euphorb. 565.”

Folia supra impresso-reticulato-venosa, 8–11 cm. longa, 2½–
 3 cm. lata, lanceolata, acuminata, basi acuta, integra, subtus fusco-
 glaucescentia. Petioli 2½–3 cm. longi. Flores ♂ : calyx 5-lobatus,
 lobis triangularibus. Stamina 5, rarius 6–7, glandulis cylindraceis
 alterna ; antheræ introrsæ, filamentis antheras æquantibus, connectivis
 apiculatis. Flores ♀

DISTRIB.: In Indiæ orientalis regione temperata, et Formosa.

HAB. Formosa : Shihun, leg. K. MIYAKE, anno 1898.

5. **D. humile** MAXIM. ex FRANCH. et SAVAT. Enum. Pl.
 Jap. II. 488.

Planta non satis nota.

11. **Croton** LINN.

LINN. Sp. Pl. ed.-2, 1424 ; ENDL. Gen. Pl. 1117 ; MUELL.
 ARG. in DC. Prodr. XV.-2, 513 ; BAILL. Hist.

d. Pl. V. 225 ; BENTH. et HOOK. Gen. Pl. III. 293 ;
 Pax, in Nat. Pfl. Fam. III.-5, 37.

Flores monoici, petaliferi. Fl. ♂ : calyx 5-partitus, segmentis anguste imbricatis. Petala segmentis calycis isomera, breviora. Disci glandulæ calycis basi affixæ v. adnatæ, staminibus exterioribus alternæ. Stamina 15-20 receptaculo affixa, exteriora calycis segmentis isomera iis alterna, filamentis liberis apice in alabastro inflexis, per anthesin erectis ; antheræ adnatæ, in alabastro infracto-incurvæ, apice inferio basi superio, dein oscillando erectæ, loculis parallelis introrsum contiguis longitudinaliter dehiscentibus. Rudimentum ovarii 0. Fl. ♀ : calycis segmenta quam in mare sæpius angustiora, calyx tamen post anthesin auctus dilatatusque. Petala vulgo subuliformia quam in mare minora. Disci glandulæ distinctæ, v. in annulum connatæ. Ovarium 3-loculare ; styli dichotome multifidi, v. bifidi. Ovula in loculis solitaria. Capsula in cocos 2 valves dissiliens. Semina laevia ; testa crustacea v. indurata ; albumen copiosum, carnosum ; embryo rectus, cotyledonibus latis planis. Indumentum e pilis stellatis sæpe ferrugineis, canescentibus v. squamellis metallice nitentibus. Folia alterna v. sub inflorescentia subverticillata, integerrima, pennivenia v. 5-nervia, basi biglandulosa. Flores ad apices ramorum v. in axillis summis spicati, fl. ♂ breviter pedicellati, fl. ♀ sessiles v. pedicellati. Bractæ parvæ, v. sub fl. ♀ auctæ.

Conspectus Crotonum Specierum.

Folia penninervia, subtus indumento albido-fulvo vesta.....1. *C. Cumingii*.
 Folia palmatinervia, subtus pilis rigidulis parce vesta.....2. *C. Tiglium*.

1. **C. Cumingii** MUELL. ARG. (Tab. III. B.)——MUELL.

ARG. in Linnæa, XXXIV. 101 et in DC. Prodr. XV.-2, 566 ;
FORBES et HEMSL. Ind. Fl. Sin. II. 434 ; HENRY, List Pl. Formos.
84.

C. polystachyum Willd.; Hook. et ARN. Bot. Beech. Voy. 270.
Nom. Jap. *Chankanii*.

Folia alterna, breviuscule petiolata, penninervia, subtus dense albido-lepidota, in apice ramorum conferta, 5–11 cm. longa, $2\frac{1}{2}$ –5 cm. lata, obovata v. elliptica, lanceolata, acuminata, basi anguste obtusa, fere integra. Fl. ♂ : calycis laciniae ovatae, margine membranaceae, fuscae, squamoso-stellato-pilosae. Petala subulata, intus basi margineque pilosa, glandulis sparsa. Stamina 15–20, receptaculo lanato-pubescenti inserta, filamentis rubris inferne pilosis, connectivis nigris. Pedicelli breves, calycis lacinias subaequantes. Fl. ♀ : calyx ut in ♂ ; petala glanduligera, truncata, calycem subaequantia, spathulata, margine et intus basi longe pilosa. Ovarium dense lepidoto-squamosum, stylis multifidis gracilibus. Capsulae 7 mm. longae, 6 mm. latae, tricoccae, coccis apice gibboso-productis. Semina oblongo-globosa, apice acuta, elegante reticulata.

DISTRIB.: In insulis Philippinis, Formosa, Liu-kiu.

HAB. Formosa : Sūbongsha, Thong-po-tsng, leg. K. MIYAKE, anno 1898 ;
Bo-tan-oan, Pak-kang-khœ, C. OWATARI, anno 1896 ; Heng-chhun, Y.
TASHIRO.

Liu-kiu : Miyakojima, Yaeyama, Okinawa, leg. Y. TASHIRO, anno 1887.

2. **C. Tiglium** LINN. (Tab. III. C.)——LINN. Sp. Pl. ed.-2, 1426 ; LOUR. Fl. Cochinch. 714 ; WILLD. Sp. Pl. IV. 453 ; AITON, Hort. Kew. V. 327 ; MIQ. Fl. Ind. Bat. I.-2, 379 ; ROXB. Fl. Ind. III. 682 ; MUELL. ARG. in DC. Prodr. XV.-2, 600 ; Hook. f. Fl. Brit. Ind. V. 393 ; FORBES et HEMSL. Ind. Fl. Sin. II.

435; HENRY, List Pl. Formos. 84; L. DIELS, in Engl. Jahrb. XXIX. 428.

Nom. Jap. *Hazu*.

Ramuli et petioli glabri. Folia 5-nervia, firma, basi biglandulosa, 5-14 cm. longa, 2-7 cm. lata, ovata, acuta, basi obtusa, margine plus minusve crenulato-serrulata, v. fere integra, petiolo vulgo duplo longiora, pilis, adpressis, vulgo brevibus, rigidulis, sparsa. Petioli 3-4 cm. longi. Stipulæ subulatæ deciduissimæ. Racemi multiflori, bracteis lanceolato-subulatis. Fl. ♂: sepala ovata, apice incrassata, intus glabra, lucida, extus pilosa, membranaceo-albida. Petala subulata, apice capitato-incrassata. Stamina 15-18, filamentis glabris, receptaculo piloso conferta: Pedicelli calyce longiores v. eum æquantes, tenues. Fl. ♀: sepala subulata, crassata. Petala angusta, sepalis alterna. Glandulæ graciles, virides. Ovarium stellato-hirtellum, stylis elongatis apice bifidis. Capsulæ magnæ, leptodermæ, pallidiores, maturæ 2 cm. longæ, 1.5 cm. latæ, ellipsoideæ, obtusæ, trigonæ, leviter longitrorsum trisulcatæ. Semina oblongo-ovoidea, apice apiculata, 12 mm. longa, 6 mm. in diametro æquantia, leviter reticulata.

DISTRIB. In India orient., Borneo, insulis Philippinis, Malaya, Formosa.

HAB. Formosa: Lok-ko-tsung, Po-li-sia, Chip-chip-koe, leg. K. MIYAKE, anno 1898.

12. *Mercurialis* LINN.

LINN. Sp. Pl. ed.-2, 1465; ENDL. Gen. Pl. 1111; MUELL.

ARG. in DC. Prodr. XV.-2, 794; BAILL. Hist. d.

Pl. V. 210; BENTH. et HOOK. Gen. Pl. III. 309;

PAX, in Nat. Pfl. Fam. III.-5, 49.

Flores monoeci, apetalii. Fl. ♂: calyx tenuiter membranaceus, in alabastro globosus, clausus, per anthesin valvatim 3-partitus. Discus 0. Stamina 16–20, in receptaculo elevato centralia, filamentis tenuibus, erectis, liberis; antherarum loculi a basi distincti, pyriformes, ex apice primum penduli demum ascendentes, superne longitudinaliter dehiscentes. Rimæ antherarum extrorsæ. Ovarii rudimentum 0. Fl. ♀: sepala 3. Disci lobi 2, lineari-subulati, carpellis alternantes. Ovarium 2-loculare; styli vix basi connati, longiusculi, divergentes, intus prominenter papilloso-stigmatosi, indivisi; ovula in loculis solitaria. Capsula didyma, in cocos 2-valves dissiliens, endocarpio crustaceo. Semina ovoidea. Herbæ perennes, glabræ, nitidæ. Folia opposita, stipulata, petiolata, vulgo crenato-serrulata, pennivenia. Racemi axillares, floribus supra medium in glomerulos paucos distantes collectis.

1. **Mercurialis leiocarpa** SIEB. et ZUCC. (Tab. III. D.)
 —SIEB. et ZUCC. Fl. Jap. Fam. Nat. Sect. Prim. 145;
 MUELL. ARG. in DC. Prodr. XV.–2, 795; MIQ. Prol. 291; FRANCH.
 et SAVAT. Enum. Pl. Jap. I. 425; FORBES et HEMSL. Ind. Fl.
 Sin. II. 436; L. DIELS, in Eng. Jahrb. XXIX. 428.

Nom. Jap. *Yama-ai*, Kwa-wi, herb., vol. 4, fol. 24; Somokudusetsu, vol. 20, fol. 63.

Folia longe petiolata, membranacea. Petioli limbum subæquantes v. eo sæpius circiter duplo breviores, 2–3 cm. longi. Folia 3–10 cm. longa, 2–4 cm. lata, oblongo-ovata, v. ovato-lanceolata, longius breviusve acuminata, basi obtusa, acutiuscula, rarius leviter cordata, crenato-serrata, supra nitida, purpurascentia, parce pubescentia, crenis apice glanduligeris, basi biglandulosa. Flores ♂: glomerato-spicati; alabastri trigoni, acuti, 2–3 glomerati.

Flores ♀ : sepalis ovatis, acutis ; ovarium dorso geminatim 2-4-muricatum, stylis ovario adpressis ; disci glandulæ angustæ, longæ, ovarium superantes.

DISTRIB.: In Japonia, Corea, China cent. .

HAB. Liu-kiu : insula Okinawa, leg. Y. TASHIRO, anno 1887.

Kiushu : prov. Hyūga, prov. Buzen, in monte Inugatake, anno 1882 ; prov. Chikuzen, in monte Tachibana, leg. K. NAGANO.

Hondo : Prov. Suwō, in tractu Yoshiki, leg. G. NIKAI, anno 1893. Prov. Kii, anno 1883 ; Prope Tokyo. Hikawa, ipse, anno 1904.

13. Mallotus LOUR.

LOUR. Fl. Cochinch. 780 ; ENDL. Gen. Pl. 1116 ;
MUELL. ARG. in DC. Prodr. XV.-2, 256 ; BENTH.
et Hook. Gen. Pl. III. 319 ; PAX, in Nat. Pfl.
Fam. III.-5, 53.

Flores dioici, apetalī. Discus 0, rarius evolutus. Fl. ♂ : calyx in alabastro globosus, clausus, per anthesin valvatim 5-partitus. Stamina ∞, receptaculo subdilatatō parum elevato imposita, filamentis liberis ; antheræ birimosæ longitudinaliter introrsum dehiscentes. Ovarii rudimentum 0. Fl. ♀ : calyx alte v. breviter 3-5-lobatus, lobis valvatis v. vix imbricatis, v. 5-partitus. Ovarium 2-3-loculare ; styli distincti v. basi connati, recurvo-patentes, indivisi, intus fimbriati v. prominenter papilloși ; ovula in loculis solitaria. Capsula globosa v. di-tri-dyma, in coccos 2 valves dissiliens. Semina globosa v. ovoidea, testa crustacea ; albumen carnosum ; embryo rectus, cotyledonibus planis, latis.—Arbores v. frutices. Folia alterna, opposita, bistipulata, petiolata, lata, sæpe ampla, integerrima, dentata v. late 3-loba, basi 3-7-nervia, glandulis disciformibus,

nitentibus, subaureis demum fuscis v. rufescentibus, adspersa, prope basin supra 2-v. multi-glandulosa. Racemi v. spicæ simplices v. paniculato-ramosi, axillares, v. ad apices ramorum paniculati. Fl. ♂ sæpius parvi, breviter pedicellati, secus rhachin glomerulati, fl. ♀ pauciores, sub quaque bractea solitarii, brevius v. longius pedicellati.

Conspectus Mallotorum Specierum.

- Folia basi pluriglandulosa; discus fl. ♀ evolutus.1. *M. moluccanus*.
 Folia basi biglandulosa; discus obsoletus.
 Folia opposita.2. *M. Playfairii*.
 Folia alterna.
 Ovarium inerme.
 Ovarium 2-loculare.....3. *M. repandus*.
 Ovarium 3-loculare.....4. *M. philippinensis*.
 Ovarium molliter echinatum.
 Folia subtus minute flaveo-glanduligera, demum utraque pagine
 glabrata5. *M. japonicus*.
 Folia ferruginea, nigra, subtus densissime breviterque stellato-
 tomentosa.6. *M. cochinchinensis*.

1. **M. moluccanus** MUELL. ARG. (Tab. III. E.)——
 MUELL. ARG. in Linnæa, XXXIV. 185; MUELL. ARG. in DC.
 Prodr. XV.-2, 958; HEMSL. in Voy. Challenger, Bot. I.-3,
 191; FORBES et HEMSL. Ind. Fl. Sin. II. 440; List Pl. Formos.
 84.

Melanolepis multiglandulosa REICHENB.; ZOLL. in Linnæa,
 XXVIII. 324.

Nom. Jap. *Yanbaru-akamegashiwa*.

Ramuli, cum juvenilibus et inflorescentibus, tomento sub-
 floccoso, fulvo, dense tecti, dein glabrati. Folia ampla, subtus
 stellato-tomentosa, ambitu suborbicularia, 5-nervia, longe petiolata,

petiolis limbum foliorum subæquantibus, sinuato dentata, dentibus mucronatis, basi pluriglandulosa, elobata v. subtrilobata, 4–16 cm. longa, late rhombeo-ovata, acuminata, basi breviter contracta v. subcordata, utraque pagine sæpe tomento flocco tecta, demum glabra. Racemi paniculato-ramosi; pedicelli longi, calycem superantes. Flores dioici casu monoici. Fl. ♀: calyx 5-partitus; ovarium oblongo-globosum, 2–3-loculare, stylis minutis, simplicibus; discus evolutus, urceolaris, crassiusculus, crenatus. Fl. ♂: calyx 5-partitus, segmentis valvatis, crassiusculis. Stamina ∞ , rubella, filamentis liberis, filiformibus, connectivis coccineis vulgo obconicis productis, antheris versatilibus; receptaculum stellato-pubescent. Capsulæ dense subpulveraceo-stellato-tomentellæ, circ. 1 cm. latæ, 8 mm. longæ, stylis persistentibus. Semina foveolata, oblongo-globosa, apice acuta, diametro 4 mm. æquantia, arillis spuriis violaceo-purpureis.

DISTRIB. In insula Java, Borneo, Timor, Philippinis, India orientali, Formosa, Liu-kia.

HAB. Formosa: Takao, San-te-chhu, leg. K. MIYAKE, anno 1898; Keng-chio-kha-tsung, Hosoang, K. MIYAKE, C. OWATARI, anno 1896.

2. **M. Playfairii**, HEMSL. (Tab. III. F.)——FORBES et HEMSL. Ind. Fl. Sin. II. 441; HENRY, List Pl. Formos. 84.

Nom. Jap. *Shima-azusa*.

Frutices parvi, ramulis crassis compressis dense et brevissime stellato-tomentosis pallidis. Folia opposita, subcoriacea, rotundato v. cordato-ovata, 5–14 cm. longa, integra v. obscure callosodentata, abrupte acuminata, supra cristis pilorum brevissimorum dense congestorum parce conspersa, subtus simul brevissime albidotomentosa, venis primariis lateralibus utrinque circiter 6, secundariis subrectis conjunctis. Petioli teretes, limbo breviores. Fl. ♂ aperientes 5 mm. diametro æquantes; calyx 4-partitus, segmentis

late ovatis vix acutis. Stamina ∞ , extrorsa, loculis antherarum connectivum superantibus. Flores brevissime pedicellati, pedicellis sepala æquantibus, fasciculatim racemosi, racemis foliis brevioribus.

HAB. Formosa : Takao, leg. C. OWATARI, anno 1897.

3. **M. repandus** MUELL. ARG. (Tab. III. G.)———
MUELL. ARG. in Linnæa, XXXIV. 197, et in DC. Prodr. XV.—2, 981; BENTH. Fl. Austral. VI. 142; HEMSL. in Voy. Chall. Bot. I.—3, 191; HOOK. f. Fl. Brit. Ind. V. 442; FORBES et HEMSL. Ind. Fl. Sin. II. 441; HENRY, List Pl. Formos. 84; L. DIELS, in Engl. Jahb. XXIX. 429.

Croton rhombifolius WILLD. Sp. Pl. IV. 555.

Rottlera trinervis ZIPP. in Linnæa, XV. 348.

R. tricocca ROXB. Fl. Ind. III. 829.

R. cordifolia BENTH. Fl. Hongk. 307.

R. scabrifolia A. JUSS.; REICHB. et ZOLL. in Linnæa, XXVIII. 319.

Trewia nudiflora HANCE, in Journ. Bot. 1878, 14.

Mallotus contubernalis HANCE, in Journ. Bot. 1882, 293.

Nom. Jap. *Tsuru-akamegashiwa*.

Ramuli juniores, cum petiolis, foliis, inflorescentiis, brevius stellato-fulvo-tomentelli. Folia longe trinervia, basi subobsolete peltata, 4–7 cm. longa, 4–5 cm. lata, ambitu varia vulgo triangulari-ovata, abrupte acuta, basi obtusa, subcordata, subintegra v. repando-denticulata, lutescenti-viridia, supra subglabra, subtus stellato-tomentella demum glabrescentia, glandulis ceraceis aureo-nitentibus adpressa, basi supra biglandulosa. Spicæ in ramulis terminales, foliis sæpe longiores, fulvæ. Bractæe ♂ 3-floræ, ♀ 1-floræ, triangulari-ovatæ, acuminatæ. Fl. ♂: calyx 4-partitus, segmentis

ovatis, acutis, glandulis pallidis majusculis adspersis. Stamina circ. 50, receptaculo parvo congesta. Fl. ♀ : calyx 4 lobatus, lobis crassiusculis, ovatis dein lanceolatis ; ovarium globosum, 2-loculare, glandulis adpressum, pubescens, stylis basi connatis intus ramuloso-papillosis.

DISTRIB. In India orientali, Ceylonia, Java, Philippinis, Formosa.

HAB. Formosa : Takao, leg. C. Owatari, anno 1897.

4. **M. philippinensis** MUELL. ARG. (Tab. III. H.)——
MUELL. ARG. in Linnæa, XXXIV. 196 et in DC. Prodr. XV.—2, 980 ; BENTH. Fl. Austral. VI. 141 ; BEDDOME, Fl. Sylv. Sau. Ind. t. 289 ; HANCE. in Journ. Linn. Soc. XIII. 122 ; HEMSL. Voy. Chall. Bot. I.—3, 190 ; Hook. f. Fl. Frit. Ind. V. 442 ; FORBES et HEMSL. Ind. Fl. Sin. II. 440 ; HENRY, List Pl. Formos. 84 ; L. DIELS, in Engl. Jahrb. XXIX. 428.

Croton montanus WILLD. Sp. Pl. IV. 545.

Rottlera tinctoria ROXB. Fl. Ind. III. 827 ; BENTH. Fl. Hongk. 307.

R. aurantiaca HOOK. et ARN. Bot. Beech. Voy. 270.

Nom. Jap. *Kusunohagashiwa*.

Ramuli juniores, petioli et inflorescentiæ pilis stellatis brevibus ferrugineo-tomentelli. Folia alterna longe triplinervia, 5–20 cm. longa, 1–4 rarius 7 cm. lata, ovato-lanceolata, v. rhombeo-lanceolata, acuminata, basi acuta, supra biglandulosa, integra v. denticulata, subtus inter indumentum brevissime tomentellum coccineo-glanduloso-pulveracea, supra glabra, demum sensim expallentia, petiolis limbo foliorum 2–4-plo brevioribus. Spiciæ axillares v. terminales, ferrugineæ, subpulveraceo-tomentellæ. Discus utriusque sexus 0. Bracteæ 1 mm. longæ, basi incrassatæ, 1-floræ, glandulis coccineis adpressæ. Fl. ♂ : sepala lanceolata, crassiuscula ; stamina

circ. 30. Fl. ♀ : calyx 2-2½ mm. longus, irregulariter 3-lobatus, lobis ovatis; ovarium dense coccineo-glandulosum, 3-loculare, stellato-tomentellum; styli basi connati ovarium subaequantes, intus fimbriato-papilloso. Capsulae inermes depresso-globosae, profunde trisulcatae, pedicello fructifero 2-3-plo longiores, 8-9 mm. latae, 6-7 mm. longae, dense coccineo-glandulosae. Semina globosa, 4 mm. longa.

DISTRIB. In India orientali latissime distributa; Ceylonia, Java, insulis Philippinis, Hongkong, Formosa, Liu-kiu.

HAB. Formosa: Kachiraisha, Thong-po-tsong, Pang-liau, K. MIYAKE, anno 1898. Taiepa, Pachina, leg. T. MAKINO, anno 1896, et C. OWATARI, anno 1897.

Liu-kiu: Okinawa, leg. Y. TASHIRO, anno 1887. Yaeyama, leg. S. TANAKA, anno 1891. Kobo, leg. M. MIYAJIMA, anno 1900.

5. **M. japonicus** MUELL. ARG. (Tab. III. I.)——
MUELL. ARG. in Linnaea, XXXIV. 189 et in DC. Prodr. XV.—2, 966; MAXIM. in Engl. Jahrb. VI. 59; FORBES et HEMSL. Ind. Fl. Sin. II. 440; HENRY, List Pl. Formos. 84; L. DIELS, in Engl. Jahrb. XXIX. 428; SHIRASAWA, Nipponshimrinjumu-kudusetsu, t. 55.

Croton japonicum THUNB. Fl. Jap. 270.

Rottlera japonica SIEB. et ZUCC. Fl. Jap. 147, t. 79.

R. japonica SPRENG.; HOOK. et ARN. Bot. Beech. Voy. 270; SIEB. et ZUCC. Fl. Jap. Fam. Nat. Sect. Prim. 144; MIQ. Prol. 291.

Nom. Jap. *Akamegashiwa*, Kwawi, arb., vol. 1, fol. 18, sub.

Arbores. Rami lignosi, teretes, glabri, ramuli cum partibus omnibus juvenilibus pilis stellatis tecti. Folia 7-14 cm. longa, 5-10 cm. lata, membranacea, suborbiculari-ovata, rhombeo-ovata, v. rhombeo-orbicularia, cuspidato-acuminata, supra repandotricuspidata, lobata, v. interdum elobata, basi haud peltata, cuneato-

subacuta, obtusa v. subcordata, triplinervia, margine integra, subtus minute flavido-glanduligera, demum utraque pagine glabrata, petiolis limbum subæquantibus, stellato-puberulis, glabrescentibus. Flores ramoso-spicato-racemosi, subferrugineo-tomentosi, terminales, bracteis triangularibus acutis interdum fidis parvis. Flores ♂ : stamina 50–60, filamentis 2 mm. longis, loculis antherarum superne subpatulis. Flores ♀ : calyx 3–5- irregulariter fidus ; ovarium dense coccineo-glandulosum, 3-loculare, stellato-tomentosum, molliter echinatum ; styli basi connati ovarium bis superantes intus dense longeque papilloso-plumosi. Capsulæ molliter echinata, glandulis adpressis, aculeis mollibus tenuibus stellato-puberulis, absque aculeis 8 mm. latæ, 5 mm. longæ, tridymæ, vinosorubellæ. Semina compresso-globosa.

DISTRIB.: in China boreali, Japonia.

HAB. Formosa : Tai-tong-thian, Phok-chih-koh, leg. K. MIYAKE, anno 1899.

Tut-chihoh, leg. K. MIYAKE, anno 1899 ; Sia-lian-to, kelung, Pilam,

Tamtsui, leg. T. MAKINO, et C. OWATARI, anno 1896.

Liu-kiu : kumesima, leg. H. KURUIWA, anno 1898.

6. **M. cochinchinensis** LOUR. (Tab. III. J.)——
 LOUR. Fl. cochinch. 635 ; MUELL. ARG. in Linnæa, XXXIV.
 189 ; Hook. f. Fl. Brit. Ind. V. 430 ; FORBES et HEMSL. Ind.
 Fl. Sin. II. 439 ; HENRY, List Pl. Formos. 84.

Trewia tricuspidata WILLD. Sp. Pl. IV. 834.

Rottlera paniculata A. J. ; BENTH. Fl. Hongk. 307 ; Hook.
 et ARN. Bot. Beech. Voy. 212 ; MIQ. Fl. Ind. Bat. I.-2, 395.

Mallotus paniculatus MUELL. ARG. in Linnæa, XXXVI.
 189 et in DC. Prodr. XV.-2, 965 ; BENTH. Fl. Austral. VI. 140.

Nom. Jap. *Annan-akamegashiwa*.

Folia longe petiolata, rhombeo-ovata, acute cuspidata, interdum lobato-tricuspidata, basi abrupte acuta, epeltata, basi biglandu-

losa, margine subintegra, subtus densissime breviterque stellato-tomentosa et ferruginea. Spicæ paniculato-ramosæ, terminales. Bracteæ ♂ 3-floræ, ♀ 1-floræ, triangulares, acutæ, breves. Calyces pilis stellatis ferrugineo-tomentelli. Fl. ♂ staminis numerosis, antheris parvis. Capsulæ multo validius appendiculato-subechinatae, absque aculeis 7 mm. latæ, 5 mm. longæ; aculei 4–5 mm. longi. Semina 3 mm. longa, ovoidea, vivo glabra, sicco rugulosa.

DISTRIB.: In Java, Borneo, Malaya, Hongkong, vulgaris.

HAB. Formosa: Su-hun, leg. C. OWATARI, anno 1897. Png-kang, Sūbonsa, Ang-thau-su, leg. K. MIYAKE, anno 1898.

14. *Alchornea* S. W.

ENDL. Gen. Pl. 1113; MUELL. ARG. in DC. Prodr. XV.–2, 899; BAILL. Hist. d. Pl. V. 212; BENTH. et HOOK. Gen. Pl. III. 314; PAX, in Nat. Pfl. Fam. III.–5, 55.

Flores dioici casu monoici, apetalii. Discus 0. Fl. ♂: calyx in alabastro globosus, clausus, per anthesin valvatim 4-partitus. Stamina 8; filamentis liberis v. sæpius basi brevissime in annulum connatis; antheræ introrsæ, loculis distinctis parallelis longitudinaliter dehiscentibus. Ovarii rudimentum 0. Fl. ♀: sepala 5, imbricata. Ovarium 3-loculare; styli distincti, lineares, indivisi; ovula in loculis solitaria. Folia alterna, serrulata, 3-nervia, basi supra 2-glandulosa. Spicæ terminales, simplices, floribus ♂ parvis secus rhachin glomeratis. Bracteæ utriusque sexus minutæ, floribus ♀ sub bractea solitariis.—Frutices. Folia alterna, petiolata stipulata.

1. **A. trewioides** MUELL. ARG. (Tab. IV. A.)——
MUELL. ARG. in *Linnaea*, XXXIV. 168 et in DC. Prodr. XV.—
2, 901.

Nom. Jap. *Amigasagiri*.

Folia longe petiolata, cordata, ovata, cuspidato-acuminata, 7–15 cm. longa, 6–14 cm. lata, basi biglandulosa, margine serrulata, stipulis lanceolatis, linearibus. Flores ♂ aperiens 5 mm. diametro æquantes, sepalis $1\frac{1}{2}$ mm. longis, triangularibus acutis. Stamina 8 biseriatim disposita, filamentis crassis. Fl. ♀ : sepala lanceolata acuminata, $2\frac{1}{2}$ cm. longa, ovarium superantia ; ovarium globosum, stylis basi connatis patulis, intus papillosis, 5 mm. longis. Flores utriusque sexus subsessiles.

DISTRIB.: In Hongkong, Liu-kiu.

HAB. Liu-kiu : leg. J. MATSUMURA, anno 1897 ; kumesima, leg. H. KURUIWA, anno 1898.

15. *Cleidion* BLUME.

ENDL. Gen. Pl. 1113 ; MUELL. ARG. in DC. Prodr. XV.—2, 984 ; BAILL. Hist. d. Pl. V. 203 ; BENTH. et HOOK. Gen. Pl. III. 320 ; PAX, in Nat. Pfl. Fam. III.—5, 58.

Flores dioici, apetalii. Fl. ♂ : calyx in alabastro globosus, clausus, per anthesin valvatim 3-partitus. Stamina receptaculo convexo v. conico dense conferta, filamentis liberis ; antheræ dorsifixæ, connectivo sæpius breviter ultra loculos producto, loculis lateralibus transverse didymis. Ovarii rudimentum 0. Fl. ♀ ... Folia alterna, petiolata, ampla, dentata, trinervia. Racemi ♂ terminales, paniculati, floribus glomeratis.

1. **C. ulmifolium** MUELL. ARG. (Tab. IV. B.)——
MUELL. ARG. in DC. Prodr. XV.-2. 984; FORBES et HEMSL.
Ind. Fl. Sin. II. 442.

Nom. Jap. *Enokifuzi*.

Ramuli teretes, densius foliosi, juniores superne leviter flexuosi, rubelli, stipulis subulatis, $2\frac{1}{2}$ mm. longis, caducis. Folia 5-10 cm. longa, 2.5-5 cm. lata, oblongo-ovata, acuminata, basi rotundata, leviter cordata, v. obtusa, grosse crenato-serrata, membranacea, obscure viridia, graciliter reticulato-venosa, petiolis 1-3 cm. longis. Racemi ♂ bracteis ovatis, acuminatis, 3-5-floribus; sepala aperiencia 2 mm. longa, ovata-acuta.

HAB. Liu-kiu : Kumesima, leg. H. KURUIWA, anno 1898.

16. *Macaranga* THOUARS.

ENDL. Gen. Pl. 1112; MUELL. ARG. in DC. Prodr.
XV.-2, 988; BAILL. Hist. d. Pl. V. 208; BENTH.
et Hook. Gen. Pl. III. 320; PAX, in Nat. Pfl.
Fam. III.-5, 59.

Flores dioici, apetal. Discus 0. Fl. ♂ : calyx in alabastro globosus, clausus, apice punctatus, per anthesin valvatim 4-partitus. Stamina 7-9, in receptaculo plano conferta, filamentis brevibus liberis; antheræ terminales, breves, 2-loculares. Ovarii rudimentum 0. Fl. ♀ : calyx per anthesin oblique spathaceus. Ovarium 2-loculare. Styli breves crassiusculi patentes, indivisi, basi breviter connati; ovala in loculis solitaria. Capsula sparse molliter echinata. Folia alterna, petiolata ampla integerrima, basi peltata. Flores ♀ spicati; ♂ racemosi, axillares, ramosi, intra bracteus numerosi,

parvi, secus rhachin glomerati, fl. ♀ intra bracteas solitarii. Bracteæ flores amplectantes, fimbriatæ.

1. **M. Tanarius** MUELL. ARG. (Tab. IV. C.)——
MUELL. ARG. in DC. Prodr. XV.-2, 997; BENTH. Fl. Austral. VI. 146; HEMSL. in Voy. Challeng. Bot. I.-3, 191; Hook. f. Fl. Brit. Ind. V. 447; FORBES et HEMSL. Ind. Fl. Sin. II. 443; HENRY, List Pl. Formos. 84.

Ricinus Tanarius LINN. Sp. Pl. ed.-2, 1430.

R. Mappa ROXB. Fl. Ind. III. 690.

Mappa moluccana WIGHT, Ic. Ind. or. t. 816.

M. Tanaria SPRENG.; BENTH. Fl. Hongk. 304; ZOLLING, in Linnæa, XXVIII. 307; MIQ. Fl. Ind. Bat. I.-2, 401.

Nom. Jap. *Obaki*.

Ramuli cum petiolis glabri, glauco-pruinosi. Folia 10-30 cm. longa, evoluta vix longiora quam lata, triangulari-orbicularia, late peltata, acuminata, basi rotundata v. obtusa, repando-denticulata v. integra, subtus granulis nitidis exguis adspersa, molliter tomentosa, stipulis 12-15 mm. longis, lanceolato-ovatis acuminatis, scariosis, fuscis, petiolis longis limbum subæquantibus. Flores ♂ paniculati, paniculis longe pedunculatis, bracteis fimbriato-dentatis, ovatis, flabellato-nervosis, cucullato-concavis, flores amplectantibus. Calyx 2-3-4-partitus, segmentis ovatis acuminatis. Fl. ♀ : ovarium depressoglobosum, stigmatis exsertis, granulis pulchre pallide cereis et ceraceis dense adpersum.

DISTRIB.: In Malaya, Formosa, Liu-kiu.

HAB. Formosa : Sia-liau-to, Pachina, kelung, leg. T. MAKINO, anno 1896; Leng-nga-liau, Hoetong, leg. C. OWATARI, anno 1896; Subonsa, Tai-tong-thian, To-loan-sia, leg. K. MIYAKE, anno 1898.

Liu-kiu : Okinawa, leg. Y. TASHIRO, anno 1887; Yaeyama, leg. S. TANAKA, anno 1893; Kobitō, leg. M. MIYAJIMA, anno 1900.

17. *Acalypha* LINN.

LINN. Sp. Pl. ed.-2, 1423; ENDL. Gen. Pl. 1111;
 MUELL. ARG. in DC. Prod. XV.-2, 800; BAILL.
 Hist. d. Pl. V. 212; BENTH. et HOOK. Gen. Pl.
 III. 311; PAX, in Nat. Pfl. Fam. III.-5, 60.

Flores monoeci, apetalii. Discus 0. Fl. ♂: calyx minimus, tenuiter membranaceus, in alabastro clausus, per anthesin valvatim 4-partitus. Stamina 8, 2-seriatim disposita, exteriora sepalis alterna, receptaculo parum elevato affixa, filamentis liberis; antheræ birimosæ; loculi subvermiformes, divaricati, oblongi, in flore aperto sæpissime flexuosi. Ovarii rudimentum 0. Fl. ♀: sepala 3, imbricata minima; ovarium 3-loculare; styli liberi, filiformes, in lacinias filiformes divisi; ovula in loculis solitaria. Capsula tridyma, parva, in cocos 2-valves dissiliens. Semina subglobosa, testa crustacea; embryo rectus; cotyledones latæ planæ.—Herbæ. Folia alterna, ovata, plus minusve dentata, petiolis longis. Flores ♂ parvi, sub bracteas parvas glomerati, in spicas amentiformes, demum articulato-decidui. Flores ♀ intra bracteam demum auctam foliaceamque 2-4-glomerati.

1. ***A. australis*** LINN. (Tab. IV. D.)——LINN. Sp. Pl. ed.-2, 1424; MUELL. ARG. in Linnæa, XXXIV. 41; FORBES et HEMSL. Ind. Fl. Sin. II. 437.

A. virgata THUNB. Fl. Jap. 268.

A. chinensis ROXB. Fl. Ind. III. 677; HOOK. et ARN. Bot. Beech. Voy. 213.

A. pauciflora HORNEM.; MAXIM. Prim. Fl. Amur. 240; MIQ. Prol. 291; FRANCH. et SAVAT. Enum. Fl. Jap. I. 421; FRANCH. Pl. David. 264.

A. gemina MUELL. ARG. in DC. Prodr. XV.-2, 886.

Nom. Jap. *Enokigusa*, Sōmokuzusetsu, XX. fol. 12.

Folia 3-7 cm. longa, 1-4 cm. lata, subrhombeo-ovata, obtusa v. acuta, apice acuminata, tenuia nunc firma, serrulato-dentata. Flores ♂: calyx 4-partitus, sepalis extus verrucosis glanduligeris; filamenta basi connata, spathulata, antheras vermiformes in longitududo æquantia. Pedicelli articulati, caducissimi. Flores ♀: calyx 3-partitus, sepalis ovatis acutis margine ciliolatis glanduligeris pubescentibus; ovarium globosum tuberculato-scabrum pubescens; styli fimbriati. Bracteæ triangulari-ovatae. Bracteæ fructigeræ 10-15 mm. longæ, virides, parce pubescentes. Capsulæ globosæ profunde trisulcatae pubescentes, 2 mm. longæ. Semina ovoidea levia 2 mm. subæquantia.

DISTRIB.: Mandshuria et Japonia.

HAB. Formosa: Kelung, leg. T. MAKINO, anno 1896.

Liu-kiu: Okinawajima, leg. Y. TASHIRO, anno 1887.

Hondo: Suwō, in tractu Yoshiki, leg. G. NIKAI, anno 1894; prov. Tushima, leg. Y. YABE, anno 1901; propo Tokyo.

2. *A. australis* L. var. *lanceolata* var. nov.

Nom. Jap. *Hosobano-enokigusa*.

Folia angustiora, 2.5-5 cm. longa, 5-7 mm. lata, lanceolata, oblongo-lanceolata, apice obtusa v. mucronata, repando-dentata v. crenata.—Rami inferne fasciculati.

HAB. Formosa: Kelung, leg. T. MAKINO, anno 1896.

18. *Ricinus* LINN.

LINN. Sp. Pl. ed.-2, 1430; ENDL. Gen. Pl. 1115;
MUELL. ARG. in DC. Prodr. 1017; BAILL. Hist.
d. Pl. V. 178; BENTH. et HOOK. Gen. Pl. III.
321; PAX, in Nat. Pfl. Fam. III.-5, 70.

Flores monoici, apetalii. Discus 0. Fl. ♂: calyx membranaceus, in alabastro globosus, per anthesin valvatim 5-partitus. Stamina in receptaculo plano-convexo conferta, numerosa, filamentis repetitoramosissimis; antherarum loculi distincti didymo-subglobosi divaricati, longitudinaliter dehiscentes. Ovarii rudimentum 0. Fl. ♀: calyx 3-spathaceo-fissus, caducissimus. Ovarium 3-loculare; styli basi connati longiusculi, patentes, ultra medium bipartiti, intus valde papilloso; ovula in loculis solitaria. Capsulæ tridymæ, in cocos 2-valves dehiscentes, magnæ, 3-spermæ. Semina ovoidea, testa crustacea, carunculata; albumen oleosum; cotyledones planæ, latæ.—Herbæ elatæ, annuæ, glabræ, glaucæ. Folia alterna, ampla, longe peltata, palmatim 7-8 lobata, lobis serratis. Racemi ad apices ramorum subpaniculati, floribus majusculis, superioribus fl. ♀ confertis, inferioribus fl. ♂ breviter pedicellatis.

1. **R. communis** LINN. Sp. Pl. ed.-2, 1430; WILLD. Sp. Pl. IV. 564; LOUR. Fl. Cochinch. ed.-2, 716; AITON, Hort. Kewensis, V. 331; HOOK. et ARN. Bot. Beech. Voy. 212; SIEB. et ZUCC. Fl. Jap. Fam. Nat. Sect. Prim. 145; HOOK. Nig. Fl. 178; MIQ. Fl. Ind. Bat. I.-2, p. 391; BENTH. Fl. Hongk. 307; Bot. Mag. t. 2209; GRISEBACH, Fl. Brit. West Ind. 37; MUELL.

ARG. in DC. Prodr. XV.-2, 1017; MIQ. Prol. 291 et in Ann. Mus. Bot. Lugd.-Bat. III. 127; SEEM. Fl. Vitiensis, 229; HEMS. in Voy. Chall. Bot. I.-2, 64 et I.-3, 191; HEMS. Biol. Cent. America, III. 131; HILLEBRAND, Fl. Hawai. 399; HOOK. f. Fl. Brit. Ind. V. 457; FORBES et HEMS. Ind. Fl. Sin. II. 443; HENRY, List Pl. Formos. 84.

Nom. Jap. *Tōgoma*, Sōmokuzusetsu, vol. 20, fol. 33.

Hima, Honzōzufu, vol. 21, fol. 23.

Folia 15–25 cm. longa, ultra medium palmato-lobata, lobis ovato-lanceolatis acuminatis inæqualiter serrato-dentatis. Flores ♂: sepala triangulari-ovata. Alabastra subglobosa leviter acuta. Pedicelli inferne articulati. Flores ♀: ovarium echinatum, stylis basi connatis. Pedicelli superne articulati. Capsulæ longitrorsum trisulcatæ. Semina lævia, eleganter maculata, valide carunculata.

DISTRIB.: Ubique loci cult.

HAB. Formosa: Taiepa, leg. T. MAKINO, anno 1896; Takao leg. C. OWATARI, anno 1896; Heng-chhun., Tomon, leg. K. MIYAKE, anno 1898.

Liu-kiu: Naha, anno 1882.

Hondo: Prope Tokyo.

19. *Homonoya* LOUR.

LOUR. Fl. Cochinch. 782; ENDL. Gen. Pl. 1125; MUELL.

ARG. in DC. Prodr. XV.-2, 1022; BAILL. Hist. d.

Pl. V. 179; BENTH. et HOOK. Gen. Pl. III. 322;

PAX, in Nat. Pfl. Fam. III.-5, 71.

Flores dioici, apetal. Discus 0. Fl. ♂: calyx in alabastro globosus, clausus, per anthesin valvatim 3-partitus. Stamina centralia numerosa; antheræ in filamentis repetiter ramosis dense

confertæ, loculis subglobosis divaricatis in filamento sessilibus, unilocularibus. Ovarii rudimentum 0. Fl. ♀: sepala 5, angusta, imbricata, inæqualia. Ovarium 3-loculare; styli indivisi, patentes, papilloso-plumosi, vix basi connati; ovarii loculi 1-ovulati, duo anteriores, bracteam spectantes, unus posterior. Frutices puberuli. Folia alterna, bistipulata, petiolata, penninervia, venosa, angusta, dentata, subcoriacea, subtus glanduloso-lepidota. Stipulæ caducissimæ. Spicæ axillares, utriusque sexus densifloræ. Bracteæ 1-floræ.

H. riparia LOUR. Fl. Cochinch. ed.-2, 637; MUELL. ARG. in Linnæa, XXXIV. 200 et in DC. Prodr. XV.-2, 1023; BEDDOME, Fl. Sylv. t. 212; HOOK. f. Fl. Brit. Ind. V. 455; FORBES et HEMSL. Ind. Fl. Sin. II. 443; HENRY, List Pl. Formos. 84.

Adelia neriifolia ROTH.; ROXB. Fl. Ind. III. 849; WIGHT, Ic. Pl. Ind. or. t. 1868.

Hemotospermum salicinum "BAILL. Etude Euphorb. 293."

Nom. Jap. *Nanban-yanagi*.

Rami teretes pubescentes. Folia 7-18 cm. longa, 1-2 cm. lata, angusta, lineari-lanceolata, acuminata, integra v. denticulata, saliciana, supra fusco-nigricantia, glabra, subtus parce pubescentia et ferrugineo-lepidota. Petioli breves, 3-5 mm. longi. Spicæ erectæ, graciles. Bracteæ 3-partitæ, imbricatæ. Fl. ♂: alabastra 2½-3 mm. diametro æquantia, globosa, puberula; sepala 3 mm. longa, ovata, acuta. Flores ♀: sepala angusta, subulato-lanceolata; ovarium globosum leviter trisulcatum muricatum puberulum, stylis intus longe papillosis, ovarium 5-6-plo superantibus.

DISTRIB.: In India, Java, Ceylonia, Formosa et Liu-kiu.

HAB. Formosa: Bi-long-tsng, Ang-thau-su, leg. Y. TASHIRO, anno 1896.

Liu-kiu: Tamitsuki, leg. K. MIYAKE, anno 1898.

20. *Aleurites* FORST.

ENDL. Gen. Pl. 1114; MUELL. ARG. in DC. Prodr. XV.-2, 723; BAILL. Hist. d. Pl. V. 183; BENTH. et Hook. Gen. Pl. III. 292; PAX, in Nat. Pfl. Fam. III.-5, 72.

Flores monoici, petaliferi. Fl. ♂: calyx junior globosus, clausus, per anthesin in lobos 2-valvatim ruptus. Petala 5; aestivatione contorta, calyce longiora. Disci glandulæ petalis alternæ. Stamina 10 biseriatim disposita, exteriora petalis opposita, receptaculo conico affixa, glandulis parvis alterna, filamentis elongatis; antheræ erectæ, adnatæ, birimosæ, loculis parallelis longitudinaliter dehiscentibus. Ovarii rudimentum 0. Fl. ♀: calyx et discus maris. Ovarium 4-loculare, styli bidivisi; ovula in loculis solitaria. Fructus magnus indehiscens, crassus. Seminum testa lignosa; albumen crassum; embryo rectus, cotyledonibus latis planis.—Arbores indumento stellari. Folia alterna, longe petiolata, ampla, basi 7-nervia, petiolo apice 2-glanduloso. Flores laxè cymosi, cymis ad apices ramorum paniculatis.

1. **A. cordata** STEUD.; MUELL. ARG. in DC. Prodr. XV.-2, 724; FORBES et HEMSL. Ind. Fl. Sin. II. 433; HENRY, List Pl. Formos. 83; L. DIELS, in Engl. Jahrb. XXIX. 430; SHIRASAWA, Nippon-Shinrinjumokudufu, I. t. 57.

Dryandra cordata THUNB. Fl. Jap. 267, t. 27.

Vernicia montana LOUR. Fl. Cochinch. ed.-2, 587.

Elæococca cordata BLUME; FRANCH. et SAVAT. Enum. Pl. Jap. I. 425.

Nom. Jap. *Abura-giri*, Honzo-zufu, vol. 83, fol. 7.

Rami ramosi glabri, densiuscule verrucoso-lenticellati. Folia 9–18 cm. longa, 7–15 cm. lata, late ovata, acuta vel acuminata, basi truncata v. levius v. profunde cordata, ambitu integra v. superne tricuspidata, firme membranacea, petiolum æquantia v. superantia v. eo breviora, basi biglandulosa, glandulis gyalectiformibus, concavis longe stipitatis, utrinque glaberrima. Pedicelli calycem æquantes, inferne sericeo-pubescentes, superne glabri. Fl. ♂ : alabastrum oblongo-ovoideum, apice obtuse cuspidatum. Calyx 2-partitus, segmentis oblongo-ovatis, acutis, apice crassiusculis, 10–12 mm. longis. Petala spathulato-lanceolata, striata, 15–17 mm. longa, 4 mm. lata; stamina filamentis subconnatis, intus pilosis. Antheræ introrsum birimosæ, in alabastro erectæ, dein post emissionem pollinis oscillando extrorsum reflexæ, tum subpendulæ, extus birimosæ, versatiles, connectivis subdilatatis. Glandulæ conico-ovoideæ acutæ. Fl. ♀ : ovarium oblongo-ovoideum 5 mm. longum, 3–3½ mm. latum, subsericeum, stylis liberis. Fructus magni, verrucosi. Semina compresso-globosa, 12 mm. longa, 13 mm. lata, oleosa

DISTRIB.: In Japonia, China.

HAB. Formosa : Loco non indicato.

Hondo : Insula Tsushima, leg. K. HIRATA, anno 1902. Prov. Suruga, prope Omiya, anno 1881; prope Tokyo, Bot. Hort.

21. *Gelonium* ROXB.

ROXB. in WILLD. Sp. Pl. IV. 831; ENDL. Gen. Pl. 1116; MUELL. ARG. in DC. Prodr. XV.-2,

1126; BAILL. Hist. d. Pl. V. 200; BENTH. et
 Hook. f. Gen. Pl. III. 324; PAX, in Nat. Pfl.
 Fam. III.-5, p. 88.

Flores dioici, apetalii. Fl. ♂: sepala 5, lata, valde imbricata. Stamina ∞ , libera, supra discum carnosum dense inserta, filamentis, linearibus, antheris oblongis, basifixis, 2-locularibus, longitudinaliter dehiscentibus. Ovarii rudimentum nullum. Fl. ♀: sepala maris. Discus membranaceus margine crenato-dentatus. Ovarium 3 loculare; styli breves, patentes, 2-fidi, ramis recurvis; ovula in loculis solitaria. Fructus globosus, endocarpio duro 3 loculari, indehiscens.—Arbores glabræ. Folia alterna brevissime petiolata, coriacea, integerrima, bistipulata, stipulis connatis, caducissimis, annulum prominulum ad nodum relinquentibus. Flores parvi. Pedicelli fasciculati, brevissimi, oppositifolia.

1. **G. æquoreum** HANCE, in Journ. Bot. (1866), 173; FORB. et HEMSL. Ind. Fl. Sin. II. 444; HENRY, List Pl. Formos. 84.

Ōwataria formosana MATSUM. in Tokyo Bot. Mag. XIV. 1.
 Nom. Jap. *Ōba-tsuge*.

Arbor ultra 10 ped. alta; truncus 1 poll. in diametro æquans, ramis griseo-suberosis, ramulis viridibus subangulatis, nodis suberosis annulatis. Folia brevissime petiolata, elliptica vel obovato-oblonga, apice rotundata, basi attenuata, $3\frac{1}{2}$ –9 cm. longa, 2– $3\frac{1}{2}$ cm. lata, integerrima, margine subrevoluta, penninervia, nervis utrinque prominulis, nervulis reticulatis, supra elevato-granulata, glaberrima. Flores 6 mm. in diametro æquantes. Sepala carneo-alba, chartacea, late orbicularia, 3 mm. in diametro æquantia, concava, margine ciliolata, glabra. Stamina ∞ , filamentis 3 mm. longis calycem excellentibus. Ovarium ovoideo-globosum, $4\frac{1}{2}$ mm. longum, glabrum.

Pedicelli subcrassi, 2 mm. longi, basi resinam exsudantes. Fructus globosus, glaber, piso major. Semina.....

HAB.: Koshūn, Fukō, leg. Y. TASHIRO, anno 1896; Kaisa, Shajō, Shōliukiūtō, leg. C. OWATARI, anno 1898.

22. Excoecaria LINN.

LINN. Sp. Pl. ed.-2, 1451; ENDL. Gen. Pl. 1109; MUELL. ARG. in DC. Prodr. XV.-2, 1213; BAILL. Hist. d. Pl. V. 227; BENTH. et HOOK. Gen. Pl. III. 337; PAX, in Nat. Pfl. Fam. III.-5, 95.

Flores dioici v. monoici, apetalī. Discus 0. Fl. ♂: sepala 3, parva distincta, imbricata; stamina 2-3, filamentis liberis; antherarum loculi distincti, ovoidei, longitudinaliter dehiscentes. Rudimentum ovarii 0. Fl. ♀: calyx 3-fidus, v. 3-partitus. Ovarium 3-loculare; styli basi breviter connati, recurvo-patentes, indivisi; ovula in loculis solitaria. Capsula tridyma, in cocci 2-valves a columella minuta dissiliens, endocarp-o crustaceo. Semina globosa, testa crustacea, albumen carnosum; cotyledones planæ, latæ. Frutices. Folia alterna longiuscule petiolata, integra, coriacea, penninervia, stipulata. Racemi terminales. Flores ♂ sub bractea 2-3 glomerati sæpius breviter pedicellati, pedicello basi 2-bracteolato.

Conspectus Excoecariarum Specierum

- | | |
|--------------------------------------|--------------------------|
| Folia coriacea. | 1. <i>E. Agallocha</i> . |
| Folia membranacea. | |
| Folia margine integra. | 2. <i>E. japonica</i> . |
| Folia margine crenato-serulata. | 3. <i>E. crenulata</i> . |

1. **Ex. Agallocha** LINN. Sp. Pl. ed.-2, 1451; WIGHT,

Ic. Pl. Ind. or. t. 1865; MUELL. ARG. in Linnæa, XXXII. 124 et in DC. Prodr. XV.-2, 1220; SEEMANN, Fl. Vitiensis, 232; BENTH, Fl. Austral. 152; HANCE, in Jour. Linn. Soc. XIII. 123; HEMSL. in Voy. Chall. Bot. I. 192; Hook. f. Fl. Brit. Ind. V. 472; FORBES et HEMSL. Ind. Fl. Sin. II. 446; HENRY, List Pl. Formos. 85; L. DIELS, in Engl. Jahrb. XXIX. 430; MATSUMURA, in Tokyo Bot. Mag. XII. 62 et 61.

Ex. Camettia WILLD. Sp. Pl. IV. 864.

Stillingia Agallocha "Baill. Etude Gen. Euphorb. 518."

Nom. Jap. *Shimashiraki*.

Rami firmi, teretes, densiuscule et patenter foliosi. Folia ovata v. elliptica 3-9 cm. longa, 2-5 cm. lata, basi obtusa, apice sæpius breviter acuminata, margine integra v. crenata, petiolis 1-2 cm. longis. Racemi axillares, solitarii. Bracteæ 1-floræ, truncatæ, dentatæ. Fl. ♀: sepala ovata, acuta; ovarium oblongo-globosum, trisulcatum, glabrum, nigricans; styli ovario breviores, basi breviter connati. Capsulæ circ. 6 mm. latæ, 4 mm. longæ profunde trisulcatæ.

DISTRIB.: In Asia meridionali late diffusa; Australia, Formosa et Liu-kiu. HAB. Formosæ: Takao.

Liu-kiu: Insula Okinawa, leg. J. MATSUMURA, anno 1897; Yaeyama, leg. S. TANAKA, anno 1891.

2. **Ex. japonica** MUELL. ARG. (Tab. IV. E.)——MUELL. ARG. in Linnæa, XXXII. 123 et in DC. Prodr. XV.-2, 1217; MIQ. in Ann. Mus. Bot. Lugd.-Bat. III. 126 et Prol. 290; HANCE, in Jour. Linn. Soc. XIII. 123; FORBES et HEMSL. Ind. Fl. Sin. II. 446; L. DIELS, in Engl. Jahrb. XXIX. 430; MATSUMURA, in Tokyo Bot. Mag. XII. 61 et 62.

Stillingia japonica SIEB. et ZUCC. Fl. Jap. Fam. Nat. Sect. Prim. 145; BENTH. Fl. Hongk. 303.

Nom. Jap. *Shiraki*,—Kwawi, arb., vol. 3, fol. 15, sub.

Rami graciles. Folia firma, membranacea, 7–17 cm. longa, 4–10 lata, ovata, basi subobtusata v. cordata, apice acuminata, costis secundariis distantibus, subtus pallidiora, stipulis longis linearilanceolatis, petiolos semiaquantibus, basi $2\frac{1}{2}$ mm. latis, fere scariosis, petiolis $1\frac{1}{2}$ –3 cm. longis. Folia subtus a margine 10–12 glandulosa, glandulis minimis, basi bi-glandulosa, glandulis majoribus. Racemi terminales. Bracteae oblongo-ovatae dentatae, glandulis crassis disciformibus subobliquis semilunaribus, fl. ♂ 3–4-florae, fl. ♀ 1-florae. Fl. ♂: calyx cupuliformis demum sub-deplanatus, 1 mm. longus. Stamina 2–3, exserta. Pedicelli $2-2\frac{1}{2}$ mm. longi. Fl. ♀: sepala 3 parva, triangularia, acuta; ovarium ovatum, trisulcatum; styli basi connati ovarium aequantes. Pedicelli crassiusculi 10 mm. longi, ovarium 3-plo superantes. Capsulae magnae, profunde trisulcatae, 10 mm. longae, 7 mm. diametro aequantes, stylis persistentibus. Pedicelli fructigeri 20 mm. longi. Semina globosa, 9 mm. diametro aequantia, nigro-maculata.

DISTRIB.: In China, Japonia.

HAB. Liu-kiu: Insula Okinawa, J. MATSUMURA, anno 1897.

Kiusiu: Prob. Buzen, in monte Iwatake, anno 1882.

Shikoku: Prov. Tosa, in monte Tsutate, anno 1888. Prov. Tosa, in tractu Wagawa, leg. T. MAKINO, anno 1889. Prov. Iyo, in monte Ishizuchi. Prov. Tosa, Yahazu, anno 1888.

Hondo: Prov. Kii, in monte Gijotoge, anno 1883. Insula Tsusima, in tractu Shishimi, leg. Y. YABE, anno 1901. Prov. Nagato, in tractu Abu, leg. G. NIKAI, anno 1893. Tokyo Bot. Hort.

3. **Ex. crenulata** WIGHT, Ic. Pl. Ind. or. t. 1865.

Ex. cochinchinensis LOUR. Fl. Cochinch. 750; MUELL. ARG. in DC. Prodr. XV.–2, 1215.

Nom. Jap. *Shima-seishiboku*.

Rami validiusculi. Folia opposita, oblongo-lanceolata, lanceolato-acuminata, basi acuta, margine crenato-serrulata, 8–12 cm.

longa, 2.5–4 cm. lata, coriacea, petiolis brevibus, 5–6 mm. longis, stipulis subulatis, parvis. Bracteæ omnes 1-floræ, breves. Fl. ♂ : calyx 3-partitus, sepalis lanceolato-ovatis; stamina 3, filamentis parum exsertis. Fl. ♀ Capsulæ depressæ, 5 mm. longæ, 8 mm. latæ. Semina subglobosa, 4 mm. lata, 5 mm. longa, levia, eleganter reticulata.

DISTRIB.: In Cochinchina, India orientali, Formosa.

HAB. Formosa: Kachinrō, leg. C. OWATARI, anno 1897.

23. *Sapium* P. BR.

MUELL. ARG. in DC. Prodr. XV.–2, 1202; BENTH. et
Hook. Gen. Pl. III. 334; PAX, in Nat. Pfl. Fam.
III.–5, 97.

Flores monoici, apetalii. Discus 0. Fl. ♂ : calyx parvus, membranaceus, dentatus. Stamina 2, filamentis liberis; antherarum loculi ovoidei, distincti, contigui, paralleli, longitudinaliter dehiscentes. Ovarii rudimentum 0. Fl. ♀ : calyx 3-fidus, ovarium 3-loculare; styli mediocaliter connati, recurvo-patentes, indivisi; ovala in loculis solitaria. Capsula columella centrali bene evoluta prædita, in cocos 2-valves dissiliens. Semina globosa, testa crustacea; embryo rectus; cotyledones planæ latæ.—Arbores glabræ. Folia alterna, petiolata, integra, pennivenia, petiolo apice 2-glanduloso. Racemi terminales, bisexuales. Flores ♂ sub bractea 3; flores ♀ ad basin spicæ plures sub bractea solitarii. Bracteæ parvæ, sæpe basi glanduliferæ.

1. *Sapium sebiferum* ROXB. Fl. Ind. III. p. 693;
Hook. et ARN. Bot. Beech. Voy. 213; MUELL. ARG. in Linnæa,

XXXII. 121; MIQ. in Ann. Mus. Bot. Lugd.-Bat. III. 126 et in Prol. 290; FRANCH. Pl. David. 266; HOOK. f. Fl. Brit. Ind. III. 470; FORBES et HEMSL. Ind. Fl. Sin. II. 445; HENRY, List Pl. Formos. 85; L. DIELS, in Engl. Jahrb. XXXIX. 430; MATSUMURA, in Bot. Mag. XVI. 163.

Croton sebiferum LINN. Sp. Pl. ed.-2, 1425.

Triadeca sinensis, LOUR. Fl. Cochinch. ed.-2, 748.

Stillingia sebifera MICHX.; HOOK. et ARN. Bot. Beech. Voy. 213; BENTH. Fl. Hongk. 302; SIEB. et ZUCC. Fl. Jap. Fam. nat. Sect. Prim. 145.

Excoccaria sebifera MUELL. ARG. in DC. Prodr. XV.-2, 1210.

Stillingia sinensis, "BAILL. Etude Gen. Euphorb. 512, t. 7, f. 26-30."

Nom. Jap. *Nankinhaze*.

Ramuli graciles, teretes, glabri. Folia longe petiolata dilatato-rhombeo-ovata, integra, sæpissime paulo latiora quam longa, basi acuta, apice acute acuminata, submembranacea, olivaceo-fuscescentia, subtus pallidiora. Petioli bene evoluti, 2-5 cm. longi. Racemi spiciformes, terminales, folium demum longe superantes, basi floribus ♀ vulgo 3-4, cæterum floribus ♂ dispositi. Bracteæ ovatæ, acuminatæ, glandulis crassis globoso-subreniformibus. Flores ♂: pedicellis medio articulatis, circ. 5 mm. longis. Calyx 1 mm. longus, cupuliformis, dentatus. Stamina exserta. Flores ♀: pedicellis 3 mm. longis. Calycis lobi triangulares acuminati, membranacei; ovarium 3 mm. longum ovoideum, stylis longis ovarium 4-plo superantibus. Capsulæ 10 mm. longæ, 13 mm. latæ, nigrae, globoso-ellipsoideæ, subacutæ. Semina incrasso-subarillata, albo sebo prædita, testis lævibus.

DISTRIB.: In Japonia, China spontanea; in Indium orientalem et partes calidas utriusque hemisphærii introducta.

HAB. Formosa : Taipea, Yensan, leg. K. MIYAKE, anno 1898 ; Hong-soang, leg. C. OWATARI, anno 1896 ; Kelung, Tamsui, leg. T. MAKINO, anno 1896 ; inter Kussaku Shinshogai, leg. K. MIYAKE, anno 1899.
Hondo : Prope Tokyo, Bot. Hort. (Cult).

24. *Euphorbia* LINN.

LINN. Sp. Pl. ed.-2, 246 ; Endl. Gen. Pl. 1108 ;
BOISSIER, in DC. Prodr. XV.-2, 8 ; BAILL. Hist.
d. Pl. V. 177 ; BENTH. et HOOK. Gen. Pl. III.
258 ; PAX, in Nat. Pfl. Fam. III.-5, 103.

Involucrum subregulare, campanulatum, turbinatum vel hemisphericum, lobis 5 v. 4, membranaceis, glandulis alternantibus, glandulis semper 4 rarius 5, substipitatis, crassiusculis, carnosis, sæpius horizontalibus v. extrorsum inclinatis, vulgo latioribus quam longis, planis v. concavis, margine exteriori rotundatis v. truncatis, semilunatis, v. bicornutis. Flores ♂ : in involucrio numerosi, pedicellati. Perianthium 0. Stamen 1, filamentum brevi cum pedicello articulato ; anthera erecta, loculis distinctis. Flores ♀ : in centro involucri 1, pedicello demum elongato ex involucrio exserto. Perianthium 0. Ovarium 3-loculare, styli 3, distincti v. plus minus coaliti, apice patentes, indivisi v. 2-fidi, ramis apice v. introrsum stigmatosis ; ovula in loculis solitaria. Capsula in cocos 2 valves a columella persistente dissiliens, endocarpio duro v. cartilagineo. Semina albuminosa, cotyledonibus latis planis, v. linearibus.

Conspectus Euphorbiarum Specierum.

Folia estipulata, alterna ; semina carunculata.

Herbæ ; folia caulina decussata ; involucri glandulæ bicornutæ...1. *E. Lathyris*.

- Frutices, ramis crassiusculis inferne denudatis superne foliosis; involucri glandulæ rotundatæ.2. *E. dendroides*.
- Herbæ; folia sparsa, involucri glandulæ margine rotundatæ.
- Bracteolæ inter flores masculos præditæ.
- Folia umbellaria 5–10.
- Folia serrulata; ovarium leve.....3. *E. Helioscopia*.
- Folia integra; ovarium verrucosum.
- Caules ramosi.4. *E. adenochlora*.
- Caules simplices.5. *E. Jolkini*.
- Folia serrulata, ovarium verrucosum.6. *E. pekinensis*.
- Folia integra, ovarium sub-læve, hirsutum. ...7. *E. togakushiensis*.
- Folia umbellaria 4.8. *E. orientalis*.
- Bracteolæ inter flores masculos non præditæ.....9. *E. ebracteolata*.
- Herbæ; folia caulina sparsa, involucri glandulæ margine retusæ v. cornutæ.
- Glandulæ semilunatæ longe bicornutæ.....10. *E. Sieboldiana*.
- Glandulæ retusæ.11. *E. Esula*.
- Folia stipulata, opposita, disticha, semina ecarunculata.
- Suffrutices.12. *E. Sparmanni*.
- Herbæ.
- Herbæ elatiores erectæ.
- Caules pubescentes.
- Semina transverse rugosa.13. *E. pilulifera*.
- Semina lævia.14. *E. hypericifolia*.
- Caules glabri.15. *E. serrulata*.
- Herbæ humiliores, prostratæ.
- Glandula appendice angustiori; capsula hirsuta.
- Folia superne facie non maculata.16. *E. thymifolia*.
- Folia superne facie maculata.....17. *E. maculata*.
- Glandula appendice latiori; capsula glabra.
- Glandula appendice elobata; folia magna; caules hirsuti.
-18. *E. humifusa*.
- Glandula appendice trilobata; folia minora; caules glabri.
-19. *E. microphylla*.

1. **E. Lathyris** LINN. (Tab. IV. F.)——LINN. Sp. Pl. ed.–2, 655; THUNB. Fl. Jap. 196; WILLD. Sp. Pl. II. 906; ARTON, Hort. Kewensis, ed.–2, III. 164; HOOK. et ARN. Bot. Beech. Voy. 44; LEDEB. Fl. Ross. III. 572; A. KANITZ, in Linnæa, XXXII. 555; SOWERBY, English. Bot. VIII. 113; BOISSIER, in

DC. Prodr. XV.-2, 99; MIQ. in Ann. Mus. Bot. Lugd.-Bat. III. 125 et Prol. 289; FRANCH. et SAVAT. Enum. Pl. Jap. I. 420; MAXIM. in Mél. Biol. XI. 833; HEMSL. Biol. cent, Americ. III. 96.

Nom. Jap. *Hanshiren*, Kwawi, herb., vol. 3, fol. 25.

„ *Zokuzuishi*, Honzōzufu, vol. 21, fol. 20.

„ *Horutosō*, Sōmokusetsu, vol. 9, fol. 23.

Caules glabri erecti crassiusculi stricti, umbellæ 4-fidæ, radiis semel bisve bifidis. Folia patula sessilia oblongo-lanceolata, integra, obtusa vel acuta, inferiora linearia, conferta, superiora remotiuscula, umbellaria conformia majora, floralia subcordata ovato-oblonga acuminata, caulina deccusata. Involucra $2\frac{1}{2}$ mm. diametro æquantia, campanulata, intus et extus glabra, lobis ovatis truncatis fimbriatis, glandulis semilunatis, bicornubus subspathulatis apice rotundatis subcrassatis maculatis, bracteis inter flores masculos obsoletis. Flores ♂: pedicellis hirtillis. Antheræ sæpe confluentes. Flores ♀: ovarium globosum, stylis longis basi coalitis bifidis apice subdilatis planis recurvis. Capsulæ maximæ ovato-depressæ trisulcatæ, 13 mm. latæ. 10 mm. longæ, coccis rotundatis. Semina ovoidea minute reticulato-rugosa, 6 mm. longa, 4 mm. lata; carunculæ orbiculares conicæ, margine lobulatæ, stipitatæ; albumen copiosum oleaginum. Embryo centralis; cotyledones crassatæ lineari-lanceolatæ radícula non latiores.

DISTRIB. In Europa australi spontanea.

HAB. Tokyo (cultâ).

2. **E. dendroides** LINN. Sp. Pl. ed.-2, 662; WILLD. Sp. Pl. II. 924; BOISSIER, in DC. Prodr. XV.-2, 109.

E. lata AIT. Hort. Kew. ed.-2, III. 164.

Nom. Jap. *Kidachi-taigeki*.

Suffrutices glabri, ramis rubellis nitidis superne dense foliosis, umbellæ 4–7-fidæ, radiis brevibus, 1 cm. longis, bifidis. Folia dense congesta, sessilia, attenuata, lineari-lanceolata, $2\frac{1}{2}$ –5 cm. longa, 5–6 mm. lata, subtus pallidiora, umbellaria breviora, 5–6-verticillata, floralia 2–4-verticillata, rhombeo-semiorbiculata mucronata lutescentia involucrium 3–4-plo superantia, 8 mm. longa, 6 mm. lata. Involucra campanulata, 2 mm. diametro æquantia, lobis oblongis, fractis, glandulis subpeltatis, transverse ovatis truncatis, concavis. Styli elongati, tenues, connati, bifidi, apice leviter incrassati. Ovarium verrucosum.

DISTRIB. Rupestris regionis mediterranæ calidioris.

HAB. Formosa : Tai-tong-thian, Tang-si-kak. Suiteiriyo, leg. K. MIYAKE, anno 1898.

3. **E. Helioscopia** LINN. (Tab. IV. G.)——LINN. Sp. Pl. ed.-2, 658 ; THUNB. Fl. Jap. 197 ; WILLD. Sp. Pl. II. 914 ; AITON, Hort. kewensis, ed.-2, III. 167 ; LEDEB. Fl. Ross. III. 562 ; BOISS. in Linnæa, XXXII. 559 ; BENTH. Fl. Hongk. 361 ; BOISS. in DC. Prodr. XV.-2, 136 ; SOWERBY, English Bot. VIII. 99 ; MIQ. in Ann. Mus. Bot. Lugd.-Bat. III. 126, et in Prol. 290 ; FRANCH. et SAVAT. Enum. Pl. Jap. I. 422 ; FRANCH. Pl. David. 263 ; MAXIM. in Mél. Biol. XI. 338 ; HOOK. f. Fl. Brit. Ind. V. 262 ; FORBES et HEMSL. Ind. Fl. Sin. II. 413 ; L. DIELS, in Engl. Jahrb. XXIX. 430.

Nom. Jap. *Tōdaigusa*, Sōmokuzusetsu, vol. 9, fol. 16.

Takusitsu, Honzōzufu, vol. 21, fol. 17.

Annuales, erectæ, superne dichotome ramosæ. Folia glabriuscula, obovato-cuneata vel spathulata, obtusa vel mucronata, sessilia, serrulata, $1\frac{1}{2}$ cm. longa, 1 cm. lata, umbellaria conformia v. obovata, majora, 2 cm. longa, $1\frac{1}{2}$ cm. lata, floralia elliptica v.

orbiculata. Involucra stipitata, turbinata, extus parce hirsuta, intus sub glandulas dense barbata, 2 mm. diametro æquantia, bracteis interfloribus masculinis gracilibus barbatis. Styli basi connati divergentes apice breviter incrassati. Capsulæ globosæ, trisulcatæ, læves, 3.5 mm. in diametro æquantes. Semina ovoidea 2 mm. longa apice compressa, favoso-reticulata; carunculæ oblique obsitæ, concavæ, ovatæ, cordatæ, orbiculares.

DISTRIB. Tota Europa et Asia.

HAB. Liukiu: Insula Okinawa, leg. Y. TASHIRO, anno 1887.

Hondo: Insula Tsushima, leg. K. HIRATA, anno 1902. Prov. Nagato, in tractu Toyoura, leg. G. NIKAI, anno 1898. Prov. Kii. Prov. Musashi, in tractu Tichibu, anno 1888, Tokyo.

4. **E. adenochlora** MORR. et DECNE. (Tab. IV. H.)

———MIQ. in Ann. Mus. Bot. Lugd.-Bat. III. 26; et Prol. 290; BOISS. in DC. Prodr. XV.-2, 176; FRANCH. et SAVAT. Enum. Pl. Jap. I. 422.

Euphorbia japonica BOISS. in DC. Prodr. XV.-2, 1266.

Nom. Jap. *Nourushi*, Sōmokusetsu, vol. 9, fol. 10 et 11.

„ *Riyo-giyo*, Sōmokusetsu, vol. 9, fol. 12.

Caulis elati, erecti, crassi, foliati, glabri, apice ramosi. Folia subtus parcissime longipilosa, inferiora 3-7 cm. longa, 8-12 mm. lata, squamiformia, reliqua 7-12 cm. longa, 2-3½ cm. lata, oblongo-elliptica, obtusa, integra, umbellaria ovato-oblonga sub anthesin radios superantia, floralia rotundato-ovata, acutiuscula; umbellæ radii 5-6, trifidi, glabri. Involucra 2½ mm. diametro æquantia, turbinata, glabra, intus barbata, lobis ovatis, undulato-repandis glabris, glandulis transverse ovatis, subreniformibus, rotundatis, substipitatis, bracteis interfloribus masculinis lanceolatis bifidis hirsutis. Styli erecti crassi, apice bifidi. Capsulæ 5 mm. diametro æquantes, depresso-globosæ, profunde trisulcatæ dorso parce

acutaeque muricatae. Semina subglobosa apice subcompressa ; laevia, 3 mm. diametro aequantia ; carunculae minutae fungiformes, caducae.

HAB. Hondo : Prov. Musashi, Wada, prope Tokyo.

5. **E. Jolkini** BOISS. in DC. Prodr. XV.-2, 121 ; MIQ. in Ann. Mus. Bot. Lugd.-Bat. III. 126 et Prol. 290 ; FRANCH. et SAVAT. Enum. Pl. Jap. I. 421 ; MAXIM. in Mél. Biol. XI. 836 ; BOISS. cent. Euphorb. 32 et Ic. Euphorb. t. 71 ; KURZ, in Journ. Bot. (1873), 193.

Nom. Jap. *Iwa-taigeki*, Sōmokuzusetsu, vol. 9, fol. 22.

Caules glabri, crassiusculi, erecti, inferne denudati cicatoricosi, superne dense foliosi, apice ramulosi, umbellae radiis 5-7 breviter bis bifidis dense corymbosis. Folia integra e basi sessilia attenuata lineari-lanceolata, obtusissima, umbellaria oblongo-elliptica radios subaequantia ; floralia e basi rotundata ovato acutiuscula. Involuera 2 mm. diametro aequantia, campanulata, stipulata, extus glabra, intus sub glandulas hirta, lobis ovatis repandis integris, glandulis transversis orbicularibus cyathiformibus, substipitatis. Styli..... Capsulae 5 mm. diametro aequantes, depresso-globosae, profunde trisulcatae, verrucis obtusis, dense obsitae, secus coecorum dorsum laeviter sulculosae. Semina subglobosa laevia 3 mm. in diametro aequantia ; carunculae orbiculares, conico-depressae, fungiformes.

DISTRIB. In Japonia.

HAB. Liu-kiu : leg. J. MATSUMURA, anno 1897 ; Kunigumi, leg. S. TANAKA, anno 1889.

Kiushiu : prope Nagasaki.

Hondō : Insula Hachijō.

6. **E. pekinensis** RUPR. (Tab. IV. J.)——RUPR. in MAXIM. Prim. Fl. Amur. 239 ; BOISS. in DC. Prodr. XV.-2, 122 ; MAXIM. in Mél. Biol. XI. 834 ; FORBES et HEMSL. Ind. Fl. Sin. II. 416 ; L. DIELS. in Engl. Jahrb. XXIX. 430.

E. lasiocaula BOISS. in DC. Prodr. XV.-2, 1266; FRANCH. et SAVAT. Enum. Pl. Jap. I. 421 et II. 485; FRANCH. Pl. David. 263.

E. Sampsinii HANCE; MAXIM. Mél. Biol. XI. 835.

E. coralloides THUNB, Fl. Jap. 197, ex MAXIM.

Nom. Jap. *Takatōdai*, Sōmokuzusetsu, vol. 9, fol. 17.

Caules herbacei rubelli molliter hispiduli ramosi, umbellæ radiis quinis 2-3-fidis dein bifidis. Folia firmula saliciformia sessilia e basi valde attenuata lanceolata acutiuscula v. acuta subintegra v. serrulata, 3-6 cm. longa, 6-16 mm. lata, superne glabra vel sparce hirsuta, subtus dense hirsuta, glaucescentia, umbellaria breviora oblongo-lanceolata, floralia ovato-rhomboida. Involucra $1\frac{2}{3}$ mm. diametro æquantia, campanulata extus glabra intus hirta, lobis ovatis retusis, glandulis transverse subreniformibus, bracteolis interfloribus masculinis barbatis. Ovarium depresso-globosum. Styli basi connati, apice bi-fidi dilatati. Capsulæ 3 mm. in diametro æquantes, globoso-depressæ, verrucis conicis obtusis sparce obsitæ. Semina $1\frac{2}{3}$ mm. longa, globoso-ellipsoidea; carunculæ oblique conicæ subsessiles.

DISTRIB. In China, Japonia.

HAB. Kiushiu: Prov. Higo, in monte Aso, leg. Y. YABE, anno 1901.

Shikoku: Tosa, leg. T. MAKINO.

Hondo: Prov. Ōmi, in monte Ibuki, anno 1881. Prov. Musashi, prope Tokyo, Prov. Hitachi. Prov. Shinano, in montibus Omine, Togakushi, Asama. Prov. Sagami, Hakone.

7. *E. togakusensis* sp. nov. (Tab. IV. A.)

Nom. Jap. *Miyama-nourushi*.

Caules glabri crassiusculi erecti herbacei rubelli apice ramosi, umbellæ radiis quinis bifidis, glabris. Folia tenuia sessilia basi rotundata oblongo-elliptica apice obtusissima v. retusa 5-7 cm.

longa, 2 cm. lata glabra, umbellaria oblongo-ovata, floralia ovata v. rhombeo-ovata. Involucra $2\frac{1}{2}$ mm. diametro æquantia campanulata extus glabra intus sub glandulas hirta, lobis ovatis retusis, glandulis transverse orbicularibus reniformibus substipitatis. Styli basi coaliti apice bifidi subincrassati. Ovarium depresso-globosum hirsutum, verrucis conicis obtusis sparce obsitum, trisulcatum, secus sulcum costata. Capsulæ 5 mm. in diametro æquantes globoso-depressæ verrucis conicis obtusissimis obsitæ v. sublæves. Semina $2\frac{1}{2}$ mm. longa globoso-compressa; carunculæ oblique conico-depressæ substipitatæ.

Ab. *E. pekinensi* RUPR. differt pro caule glabro, crassiusculo, foliis oblongo-ellipticis integris glabris, ovario hirta costato, facile distincta.

HAB. Hondō: Prov. Kaga, in monte Hakusan, anno 1881. Prov. Ecchiu prov. Shinano, in monte Togakushi, (ipse) anno 1900.

8. ***E. orientalis*** LINN. Sp. Pl. ed.-2, 660; WILLD. Sp. Pl. II. 917; AITON, Hort. kewensis, ed.-2, III. 168; LEDEB. Fl. Ross. III. 566; BOISS. in DC. Prodr. XV.-2, 121, et Ic. Euphorb. 19, t. 72.

Nom. Jap. *Shima-taigeki*.

Caules glabri crassi erecti, umbellæ radiis 7-8 simplicibus. Folia sessilia membranacea uninervia lanceolata, acuminata, integra, 7-8 cm. longa, 8-10 mm. lata, umbellaria breviora oblongo-lanceolata, floralia ovato-rhombea mucronata. Involucra $2\frac{1}{2}$ mm. in diametro æquantia, turbinato-campanulata extus glabra sub glandulas hirsuta, lobis oblongis acutis breviter ciliatis, bracteolis interfloribus masculinis. Styli a medio connati apice bifidi. Ovarium globosum trisulcatum, secus dorsa loculorum ad latus sulculorum verrucis compressis brevibus conicis obtusissimis obsitum.

HAB. Formosa: Taichū-perfect., Daibohosho, leg. R. SATAKE, anno 1898

9. **E. ebracteolata** sp. nov. (Tab. IV. I.)Nom. Jap. *Marumi-nourushi*.

Caules erecti crassati glabri v. sparce pubescentes superne ramosi, umbellæ radiis quinis bifidis, 9–10 cm. longis. Folia magna, 7–12 cm. longa, 2–3½ cm. lata, membranacea, oblongo-elliptica, oblongo-ovata, ovato-spathulata, basi leviter attenuata, apice obtusa v. retusa, glabra, subtus parce pubescentia, umbellaria conformia breviora angustiora, floralia basi truncata v. subcordata triangularia, ovato-triangularia, obtusa, 3–3½ cm. longa, 2–2½ cm. lata. Involucra campanulata, majora breviora, sessilia, 4 mm. diametro æquantia, extus glabra, intus glabra v. fauce leviter hirtilla, lobis ovatis fimbriatis, glandulis transversis semiorbicularibus integris, bracteolis interfloribus masculinis obsoletis v. minutissimis. Styli e basi connati apice breviter bifidi subincrassati. Ovarium pedicellis longis apice dilatatis rudimentum calycis formantibus, globosum, læve, non sulcatum. Capsulæ leviter trisulcatæ, læves.

Pro bracteolis interfloribus masculinis obsoletis, ovario levi facile distincta.

HAB. Hondō: Prov. Musashi, Tichibu, in monte Bukosan, leg. T. MAKINO, anno 1888,

Yezo: Sapporo, leg. K. MIYAKE, anno 1891; Prov. Hidaka, Kirimaſu, anno 1884.

10. **E. Sieboldiana** MORR. et DECNE. (Tab. VI. B.)——
MIQ. in Ann. Mus. Bot. Lugd.-Bat. III. 126 et in Prol. 290; BOISS. in DC. Prodr. XV.-2, 158; FRANCH. et SAVAT. Enum. Pl. Jap. I. 422; MAXIM. in Mém. Biol. XI. 838; BOISS. Ic. Euphob. t. 104.

E. coralloides L. Sp. Pl. ed.-2, 569; WILLD. Sp. Pl. II. 916; THUNB. Fl. Jap. 197; AITON, Hort. Kew. ed.-2, III. 168.

E. Guilielmi A. GRAY. Bot. Jap. 406.

Nom. Jap. *Natsutōdai*—Sōmokuſuſeſu, vol. 9, fol. 13.

Caules glabri tenui herbacei simplices erecti, umbellæ radiis tenuibus 5–6, divergentibus, 3–5 cm. longis, bifidis, trifidis dein bifidis. Folia integra membranacea superne subsessilia inferne petiolata brevissima subtus glaucescentia e basi attenuata oblongo-spathulata v. oblonga obtusa v. retusa, 3–6 cm. longa, 1–2 cm. lata, umbellaria conformia majora oblongo-spathulata v. oblongo-rhombea, 4–7 cm. longa, 2–3 cm. lata, floralia e basi truncata v. subcordata, triangularia v. oblongo-triangularia acuta vel acutiuscula. Involucra 3 mm. longa, $2\frac{1}{2}$ mm. diametro æquantia, turbinato-campanulata extus et intus glabra, lobis ovatis ciliatis, glandulis transverse elongatis bicornubus subparallelibus 2 mm. longis. Styli longi ad medium coaliti longe bifidi, $1\frac{1}{2}$ mm. longi. Capsulæ globosæ, profunde trisulcatæ, læves, 4 mm. in diametro æquantes. Semina ovoidea lævia, fusca, glabra, 2 mm. longa, $1\frac{1}{2}$ mm. diametro æquantia; carunculæ suborbiculares convexiusculæ.

DISTRIB.: In Japonia vulgaris.

HAB. Hondo: Prov. Musashi, Kokubungi, leg. T. MAKINO, anno 1894.

Prope Tokyo, Kamiitabashi, anno 1878; Prov. Sagami, in monte Ōyama, leg. S. MATSUDA, anno 1900. Prov. Shinano, in monte Togakushi, anno 1884. Prov. Uzen, in monte Yodono-san, anno 1887. Prov. Izu, Insula Kozushima, insula Oshima.

Hokkaido: Sapporo, leg. K. MIYABE, anno 1891.

11. **E. Esula** LINN. Sp. Pl. ed.-2, 660; WILLD. Sp. Pl. II. 919; AITON, Hort. Kew. ed.-2, III. 169; LEDEB. Fl. Ross. III. 576; MAXIM. Prim. Fl. Amur. 238; BAKER et MOORE, in Journ. Linn. Soc. XVII. 386; SCHMIDT, in Memoir Acad. imp. Scien. st.-Peter. VII. ser XII.-2. 60; BOISS. in DC. Prodr. XV.-2, 160; MAXIM. Mém. Biol. XI. 839; SOWERBY, English Bot. VIII. 105; HANCE, in Journ. Bot. (1875) 184, et (1878) 14; DEBEUX, Fl. Shangh. 53; FORBES et HEMSL. Ind. Fl. Sin. II. 412; L. DIELS, in Engl. Bot. Jahrb. XXIX. 430.

Nom. Jap. *Hagikusō*,—*Sōmokuzusetsu*, vol. 9, fol. 15.

Caules erecti, glaucescentes; umbellæ radiis 6–7, bis bifidis. Folia oblongo-lanceolata v. lineari-lanceolata v. spathulata obtusissima v. mucronata basi attenuata inferiora sæpe subpetiolata, 2 cm. longa, 3 mm. lata, umbellaria breviter obovata vel obovato-lanceolata, floralia rhombeo-ovata v. reniformia retusa. Involucra 2 mm. diametro æquantia campanulata, extus et intus glabra, lobis triangularibus bifidis fimbriatis, glandulis brevissime bicornutis, bracteolis interfloribus masculinis gracilibus, pedicellis fl. ♂ parce pubescentibus. Capsula.....

DISTRIB.: In Europæ pratis et humidis.

HAB: Honlo, prov. Mikawa, in tractu Akumi, leg. NAKURA, anno 1892.

12. **E. Sparmanni** BOISS. (Tab. V. A.)——BOISS. Cent. Euphorb. 5; BENTH. Fl. Austral. VI. 46; Maxim. Mél. Biol. XI. 831; FORBES et HEMSL. Ind. Fl. Sin. II. 417.

E. ramosissima BOISS. in DC. Prodr. XV.–2, 14; Hook. et ARN. Bot. Beech. Voy. 69.

Nom. Jap. *Ōagari-nishikisō*.

Caules glabri, rubelli, denudati, ad nodos incrassati, ramulis tenuibus foliosis. Folia opposita integra, basi cordata, disticha ovata, mucronata subtus glauca palmatim 3–5-nervia, 1–2 cm. longa, 6–10 mm. lata, stipulæ oblongæ fimbriato-ciliatæ magnæ rufescentes. Cymæ terminales densæ v. axillares. Involucra longe pedicellata turbinata campanulata extus glabra intus sub glandulas hirtilla, lobis triangularibus sæpe tridentatis, glandulis substipitatis rotundatis, appendice alba eis angustiori, bracteolis interfloribus masculinis spathulatis ciliatis. Styli breves bifidi. Capsulæ 2½ mm. diametro æquantes, læves globoso-depressæ, coccis subcarinatis.

Semina laevia globoso-tetragona, ad medium faciei exterioris elevatione longitudinali.

DISTRIB. In India orientali, insulis Pitcairn, Liu-kiu, Formosa.

HAB. Formosa : Ang-than-su, K. MIYAKE, anno 1897.

Liu-kiu : leg. J. MATSUMURA, anno 1897, et leg. S. TANAKA, anno 1891 ;
insula Okinawa, leg. Y. TASHIRO, et insula Ōgari, leg. Y. TASHIRO,
anno 1887.

13. **E. pilulifera** LINN. (Tab. V. B.)——LINN. Sp. Pl. ed.-2, 651 ; WILLD. Sp. Pl. II. 897 ; HOOK. et ARN. Bot. Beech. Voy. 213 ; MIQ. Fl. Ind. Bat. I.-2, p. 420 ; BENTH. Fl. Hongk. 302 ; GRISEBACH, Fl. Brit. West. Ind. 54 ; BOISS. in DC. Prodr. XV.-2, 21 ; MIQ. in Ann. Mus. Bot. Lugd.-Bat. III. 125 ; et Prol. 289 ; SEEMANN, Fl. Vitiensis, 216 ; BENTH. Fl. Austral. VI. 51 ; FRANCH. et SAVAT. Enum. Pl. Jap. I. 420 ; MAXIM. in Mém. Biol. XI. 831 ; HEMSL. in Voy. Challeng. Bot. I.-2, 22 et I.-3, 187 ; HEMSL. Bot. Cent. America, III. 98 et IV. 108 ; HILLEBRAND, Fl. Hawai. 397 ; HOOK. f. Fl. Brit. Ind. V. 250 ; FORBES et HEMSL. Ind. Fl. Sin. II. 416 ; HENRY, List Pl. Formos. 81.

E. hirta THUNB. Fl. Jap. 196 ; ROXB. Fl. Ind. II. 472.

Nom. Jap. *Shima-nishikisō*.

Caules erecti v. ascendentes simplices vel parce ramosi, toti crispulo-pubescentes, superne dense flavido-setulosi. Folia basi breviter petiolata valde inaequalia cuneata v. oblongo-lanceolata v. ovato-rhombea acuta serrulata dentatave, 1.5–4 cm. longa, 5–15 mm. lata, stipulae minimae lineares acuminatae. Involucra $\frac{1}{2}$ mm. in diametro aequantia, minima, turbinata, hirsuta, intus glabra, lobis ovatis fimbriatis, glandulis orbicularibus $\frac{1}{2}$ f. concavis, appendicibus obsoletis v. angustissimis, bracteolis interfloribus masculinis spathulatis fimbriatis. Cymae axillares sessiles vel breviter pedunculatae globoso-capituliformes, polycephalae. Styli breviores bilobi apice

incrassati. Capsulae $1\frac{1}{4}$ mm. in diametro æquantes depresso-globosæ profunde trisulcatae flavido-hirsutæ, coccis compresso-carinatis. Semina $\frac{1}{2}$ mm. longa $\frac{1}{4}$ mm., lata, rubella, acute oblongo-tetragona, transverse irregulariter rugulosa.

DISTRIB. In tota America tropica a Florida et Novo Mexico ad Brasiliam meridionalem; in Africa tropica occidentali et orientali, India orientali omni insulis Sundaicis, Philippinis, China, Formosa et Hongk.

HAB. Formosa: Taipea. Klung, leg. T. MAKINO, anno 1896. Tai-tong-thian, Tai-kah-khœ, Gi-lan-thian, Toa-o-tsng, leg. K. MIYAKE, anno 1899; Tsui-tng-lau, Hokukokei, leg. C. OWATARI, anno 1898. Heng-chhun. Sei-mon, leg. Y. TASHIRO, anno 1898.

Liu-kiu: insula Miyakosima, Okinawa, Yaeyama, leg. Y. TASHIRO, anno 1887.

14. **E. hypericifolia** LINN. (Tab. V. C.)——LINN. Sp. Pl. ed.-2, 650; WILLD. Sp. Pl. II. 895; AITON. Hort, kew. III. 161; BENTH. Fl. Hongk. 301; HOOK. Niger Fl. 176; GRISEBACH, Fl. Brit. West. Ind. 54; BOISS. in DC. Prodr. XV.-2, 23; MAXIM. in Mél. Biol. XI. 832; HEMSL. in Voy. Challeng. Bot. I.-1. 63, et I.-2, 22; HOOK. f. Fl. Brit. Ind. V. 249; HEMSL. Biol. Cent. America, III. 96; FORBES et HEMSL. Ind. Fl. Sin. II. 414.

E. parviflora LINN.; ROXB. Fl. Ind. II. 472; BOISS, in DC. Prodr. XV.-2, 22.

Nom. Jap. *Unrin-nishikisô*.

Caules pubescentes erecti simplices vel parce dichotome ramosi, ramis tenuibus. Folia brevissime petiolata oblonga vel oblongo-elliptica obtusa vel acutiuscula serrulata, 8–10 mm. longa, 4–5 mm. lata, basi rotundata vel subcordata, stipulae triangulares bifidae. Cymæ axillares pedunculatae oligocephalæ, tenues folio breviores. Involucra minima, $\frac{1}{2}$ mm. in diametro æquantia, turbinata extus glabra intus fauce hirtilla, lobis lanceolatis acuminatis integris, glandulis orbicularibus concavis, appendice alba rotundata glandula

multo latiori, sæpe biloba, bracteolis interfloribus masculinis gracilibus trifidis. Styli breves profunde bifidi. Capsulæ $1\frac{1}{2}$ mm. in diametro æquantes hirtillæ profunde trisulcatæ, coccis rotundatis. Semina 1 mm. longa, rubella ovato-quadrangula lævia v. minute tuberculata ad microscopium spectantia.

DISTRIB. In utriusque hemispherici tropicis abunde diffusa.

HAB. Formosa : Tha-li-bu-koe, leg. Y. TASHIRO, anno 1895.

15. **E. serrulata** REINW. (Tab. V. D.)——WILLD. Sp. Pl. II. 892; MIQ. Fl. Ind. Bat. I.-2, 421; BOISS. in DC. Prodr. XV.-2, 25; BENTH. Fl. Austral. VI. 51; MAXIM. in Mél. Biol. XI. 832; FORBES et HEMSL. Ind. Fl. Sin. II. 417; HENRY, List Pl. Formos. 81.

E. Vachellii, HOOK. et ARN. Bot. Beech. Voy. 213.

Nom. Jap. *Miyakojima-nishikisō*.

Caules erecti simpliciusculi glabri. Folia breviter petiolata basi subcordata vel rotundata lineari-lanceolata acutiuscula remote serrulata uninervia, 2-2.5 cm. longa, 4-5 mm. lata, stipulæ interpetiolæ dentatæ. Cymæ axillares et terminales oligocephalæ capitatae foliolis linearibus intermixtæ. Involucra $\frac{2}{3}$ mm. in diametro æquantia, campanulata extus glabra intus hirtilla, lobis lanceolatis denticulatis, glandulis minimis concaviusculis subrotundatis, appendice alba petaloidea orbiculari emarginata integra multo latiori, bracteolis interfloribus masculinis lineari-spathulatis bi-trifidis hirtillis. Styli breviores apice bifidi. Capsulæ 1 mm. in diametro æquantes, globoso-depressæ, in periphero triangulares, acute carinatae. Semina $1\frac{1}{4}$ mm. in longitudine æquantia, nigra quadrangulo-ovoidea transverse rugulosa.

DISTRIB. In insulis Philippinis, Timor, Celebes, Formosa, Liu-kiu.

HAB. Formosa : Siu-tek, leg. T. MAKINO, anno 1896.

Liu-kiu : Prope Shuri, leg. K. MIYAKE, anno 1898 ; Insula Okinawa, leg. Y. TASHIRO, anno 1887.

E. thymifolia LINN. (Tab. V. E.)——LINN. Sp. Pl. ed.-2, 651 ; THUNB. Fl. Jap. 196 ; WILLD. Sp. Pl. II. 898 ; AITON, Hort. Kew. III. 162 ; ROXB. Fl. Ind. II. 473 ; BENTH. Fl. Hongk. 302 ; BOISS. in DC. Prodr. XV.-2, 47 ; HEMSL. in Voy. Challeng. Bot. I.-2, 22 ; HEMSL. Biol. Cent. America, III. 101 ; MAXIM. in Mél. Biol. XI. 833 ; HOOK. f, Fl. Brit. Ind. V. 252 ; FORBES et HEMSL. Ind. Fl. Sin. II. 417 ; HENRY, List Pl. Formos. 81 ; HOOK. et ARN. Bot. Beech. Voy. 213 ; MIQ. Fl. Ind. Bat. I. 420.

Nom. Jap. *Iriomote-nishikisō*.

Caules filiformes prostrati ramosissimi hirsuti. Folia petiolata basi subæqualia oblonga v. oblongo-elliptica obtusa v. acutiuscula remote serrulato-crenulata, 6-9 mm. longa, 3-4 mm. lata, pagina supra glabra subtus sæpe parce hirtilla, stipulæ lanceolatæ fimbriato-ciliatæ. Involucra $\frac{1}{2}$ mm. diametro æquantia, axillaria, solitaria, a internodiorum brevitæte racemulos axillares brevissimos formantia, turbinata extus adpresse hirta intus hirtilla, lobis triangularibus acutis, ciliatulis, glandulis rotundatis concaviusculis stipitatis, appendice angusta v. obsoleta, bracteolis interfloribus musculinis gracilibus ciliatis. Styli longiores bifidi. Capsulæ subglobose, 1 mm. diametro æquantes, adpresse hirtæ, obtuse carinatæ, erectæ, brevissime stipitatæ. Semina rubella $\frac{3}{4}$ mm. longa, oblongo-tetragona transverse 5-6-sulcata.

DISTRIB. In tropicis totius fere orbis.

HAB. Formosa : Kelung, Taipea, Tamsui, leg. T. MAKINO, anno 1896 ; Heng-chhun, leg. Y. TASHIRO, anno 1868. Tsui-tng-lau, Pak-kang-khoc, leg. C. OWATARI, anno 1898 ; Takao, Giran-perfect.: Tai-ko-shō, leg. K. MIYAKE, anno 1899.

Liu-kiu : Insula Yaeyama, leg. Y. TASHIRO, anno 1887.

17. **E. maculata** LINN. (Tab. V. F.)——LINN. Sp. Pl. ed.-2, 652 ; WILLD. Sp. Pl. II. 896 ; AITON, Hort. Kew. III. ed.-2, 162 ; GRISEBACH, Fl. Brit. West. Ind. 53 ; BOISS. in DC. Prodr. XV.-2, 46 ; HEMSL. in Voy. Challeng. Bot. I.-2, 63, et BIOL. Cent. America, III. 97.

Nom. Jap. *Konishikisō*.

Caules filiformes, prostrati, crispuli hirtuli ramosissimi. Folia breviter petiolata basi valde inæqualia oblongo-elliptica v. oblongo-lanceolata acutiuscula versus apicem serrulata, 6–7 mm. longa, 2–3 mm. lata, supra brunneo-maculata, stipulæ lanceolatæ denticulatæ fissæ. Involucra axillaria internodiorum brevitare racemulos breves formantia, pedicellata turbinata extus et intus hirtilla lobis lanceolatis, fimbriatis, glandulis transverse rotundatis concavis, appendice angustiori v. obsoleta, bracteolis interfloribus masculinis gracilibus hirsutis. Styli breviores, bifidi, apice incrassati. Capsulæ 1½ mm. in diametro æquantes globoso-depressæ adpresse hirtæ, coccis obtuse carinatis. Semina 1 mm. longa quadrangulo-ovoidea transverse 3–4-sulcata. Planta ab America ad Japoniam introducta.

DISTRIB. In America boreali a Canada ad Floridam et Texas.

HAB. Prope Tokyo, leg. T. MAKINO, anno 1894.

18. **E. humifusa** WILLD. (Tab. V. G.)——LEDB. Fl. Ross. III. 557 ; BOISS. in DC. Prodr. XV.-2, 30 ; MIQ. in Ann. Mus. Bot. Lugd-Bat. III. 125 et Prol. 289 ; FRANCH. et SAVAT. Enum. Pl. Jap. I. 420 ; FRANCH. Pl. David. 262 ; MAXIM. in Mém. Biol. XI. 832 ; DEBEUX, Fl. Shangh. 53 ; FORBES et HEMSL. Ind. Fl. Sin. II. 414 ; HENRY, List Pl. Formos. 81 ; L. DIELS, in Engl. Jahrb. XXIX. 430.

E. thymifolia THUNB. Fl. Jap. 196.

Nom. Jap. *Nishikisō*, Sōmokuzusetsu, vol. 9, fol. 24.

Caules prostrati filiformes tenuiter patuli hispiduli v. glabri, dichotome ramosi. Folia basi valde inæqualia oblonga, oblongo-elliptica obtusa serrulata, glabra, sæpe subtus hirtula, 6–12 mm. longa, 3–6 mm. lata, stipulæ lineari-lanceolatæ sæpe trifidæ. Involucra solitaria internodiorum brevitæ sæpe congesta, turbinato-campanulata, intus et extus glabra, lobis triangularibus subdentatis, glandulis transverse ellipticis v. rotundatis substipitatis, appendice angustiori integra, bracteolis interfloribus masculinis linearibus. Capsulæ $1\frac{1}{2}$ mm. diametro æquantes, glabræ, coccis obtuse carinatis. Semina 1 mm. longa oblongo-tetragona glabra.

DISTRIB.: In Mongolia, Siberia et Japonia.

HAB. Hondo : prope Tokyo, leg. T. MAKINO; prov. Suwō, in tractu Yoshiki, leg. G. NIKAI, anno 1892.

Shikoku : prov. Tosa, in tractu Takaoka, leg. T. MAKINO.

19. **E. microphylla** HEYNE, (Tab. V. H.)——HOOK.
f. Fl. Brit. Ind. V. 252.

E. chamæsyce ROXB. Fl. Ind. II. 473.

E. serpens ♂ ENGELM.; BOISS. in DC. Prodr. XV.–2, 30.

Nom. Jap. *Kobano-nishikisō*.

Caules filiformes prostrati dichotome ramosi. Folia 2–3 mm. longa, $1\frac{1}{2}$ –2 mm. lata valde inæqualia subcordata ovata v. ovato-elliptica integra obtusa, stipulæ triangulares apice denticulatæ. Involucra axillaria solitaria, internodiorum brevitæ approximata, turbinato-campanulata extus et intus subglabra, lobis ovatis 2–3-fidis, glandulis transverse oblongis, appendice 2–3-lobata. Styli breviores bifidi apice subincrassati. Capsulæ $1\frac{1}{2}$ mm. diametro æquantes, coccis acute carinatis. Semina 1 mm. longa, ovato-tetragona tenuiter rugulosa.

DISTRIB.: in India orientali.

HAB. Formosa : Tamtsui, leg. T. MAKINO, anno 1896.

BUXACEÆ.

Conspectus Generum.

Folia alterna.	1. <i>Pachysandra</i> .
Folia opposita.	2. <i>Buxus</i> .

1. *Pachysandra* MICHX.

ENDL. Gen. Pl. 1123; MUELL. ARG. in DC. Prodr. XVI.-1, 21; BAILL. Hist. d. Pl. VI. 49; BENTH. et HOOK. Gen. Pl. III, 267; PAX, in Nat. Pfl. Fam. III.-5, 132.

Flores monoici, apetalii. Discus 0. Fl. ♂: sepala 4, 2-seriatim imbricata. Stamina 4, sepalis opposita, filamentis liberis exsertis crassiusculis; antheræ introrsæ, oblongæ, loculis adnatis, parallelis, longitudinaliter dehiscentibus. Rudimentum ovarii vertice truncatum. Fl. ♀: sepala 4, 2-seriatim imbricata. Ovarium 4-loculare; styli basi subdistincti, erecti, longiusculi, superne patentes, indivisi; ovula in loculis solitaria. Drupa, epicarpio in sicco laxo in vivo verisimiliter pulposo, endocarpio tenuiter crustaceo. Semina pauca, obovoideo-oblonga, testa crustacea nitida —Herbæ basi procumbentes radicalesque, ramis adscendentibus apice foliatis. Folia alterna, petiolata, latiuscula, grosse dentata,

triplinervia. Spicæ longiusculæ, floribus ♀ ad basin spicæ pauce dispositis, cæteris ♂. Flores sub bracteis alternis solitarii fl. ♂ sessiles, fl. ♀ breviter pedicellati.

P. terminals SIEB. et ZUCC. (Tab. VI. F.)——SIEB. et ZUCC. Fl. Jap. Fam. Nat. Sect. Prim. 142; BAILL. Mono. Bux. et Styl. 57; MIQ. in Ann. Mus. Bot. Lugd-Bat. III. 128, et Prol. 292; MUELL. ARG. in DC. Prodr. XVI.-1, 21; FRANCH. et SAVAT. Eum. Pl. Jap. I. 428; FORBES et HEMSL. Ind. Fl. Sin. II. 419; L. DIELS in Engl. Jahrb. XXIX. 431.

Nom. Jap. *Fukkisō*, Sōmokuzusetsu, vol. 20, fol. 24.

Caules semipedales, undique foliati, sed demum casu foliorum basi nudati, cum reliquis partibus glabri. Folia 4–8 cm. longa, 2–3 cm. lata, in petiolum 2–2.5 cm. longum decurrentia, e basi cuneata, obovata, apice obtusa v. truncata, v. etiam acuta, a medio sursum grosse remoteque serrata, subcoriacea; serrae deltoideæ, inæquales, acutæ, adpressæ. Spica terminalis, solitaria, minus multiflora erecta. Flores masc. numerosiores, vulgo bibracteolati; bracteolæ late ovatæ cum sepalis margine tenuiter ciliolatæ subcoriaceæ, circ. 2 mm. longæ. Sepala orbiculari-ovata, obtusa. Stamina longe exserta. Rudimentum ovarii truncatum quadrangulum concavum. Flores foem. pauci pedicellati; bracteolæ ovatæ acutæ, coriaceæ, magnitudine sensim in sepala abeuntes, circ. 2 mm. longæ. Sepala triangulari-ovata acuta. Styli reflexi calycem longius superantes.

DISTRIB.: In Japonia, China centrali.

HAB. Hondō: Prov. Suruga, Hakone, leg. Y. YABE, anno 1901. Prov. Hida; prov. Echigo, in monte Gozu; prov. Iwashiro in tractu Aidzu; prov. Sado, in monte Kinpokusen, et monte Haguro.

Yezo: Sapporo.

2. *Buxus* L.

LINN. Sp. Pl. ed.-2, 1394; ENDL. Gen. Pl. 1123;
 MUELL. ARG. in Prodr. XVI.-1, 14; BAILL. Mon.
 Bux. et Styl. 58, et Hist. d. Pl. VI. 48; BENTH.
 et HOOK. Gen. Pl. III. 19; PAX. in Nat. Pfl.
 Fam. V.-5, 133.

Flores monoici, apetalii. Discus 0. Fl. ♂: sepala 4, 2-seriatim imbricata. Stamina 4, sepalis opposita, filamentis validis subcomplanatis liberis exsertis crassiusculis; antheræ, oblongæ demum recurvæ, loculis introrsum adnatis parallelis longitudinaliter dehiscentibus. Rudimentum glandulosum ovarii compressum truncatum v. apice dilatatum 4-lobatum. Fl. ♀: sepala 6, decussatim biserialia valde imbricata, exteriora minora, cum stigmatibus alternantia. Ovarium 3-loculare; styli breves, crassi, inter se distantes; ovarii apex inter stylos glanduloso-3-lobatus. Capsula ovoidea, stylis persistentibus 3-cornuta, loculicide dehiscens, valvis indivisis stylis fissis 2-cornutis, pericarpio indurato, endocarpio soluto cartilagineo. Semina oblonga, 3-quetra, caruncula parva, testa subcrustacea nigra nitida; albumen oleagineum subcarnosum; embryo centralis, cotyledones oblongæ radícula non latiores. Frutices ramosissimi, glabri. Folia opposita, breviter petiolata, integerrima, coriacea, pennivenia. Spicæ in axilla foliorum solitariae breves, v. terminales. Bracteæ numerosæ, sepala similes. Flores terminales sæpe ♀, axillares ♂, breviter pedicellati.

1. *B. sempervirens* LINN. var. *japonica* (MUELL. ARG.)

MAKINO (Tab. VI. C.)——MAKINO, in Tokyo Bot. Mag. IX. (1895) 281 et XV. (1901), 169.

B. japonica MUELL. ARG. in DC. Prodr. XVI. 1, 20; MIQ. Prol. 292; FRANCH. et SAVAT. Enum. Pl. Jap. I. 428; PAX, in Nat. Pfl. Fam. III.—5, 133.

B. sempervirens THUNB. Fl. Jap. 77; FORBES et HEMSL. Ind. Fl. Sin. II. 418.

Nom. Jap. *Asama-tsuge*, *Tsuge*, vel *Benten-tsuge*, Honzōzufu, vol. 92, fol. 17.

Ramuli glabri. Folia 10–25 mm. longa, 8–12 mm. lata, obovata, apice emarginata, v. mucronata, basi acuta v. attenuata, ad petiolos puberula, petiolis brevibus margine pilosiusculis subtus convexis, supra obtuse canaliculatis. Inflorescentiæ (partes dense imbricatæ) subglobosæ basi bracteis sterilibus ovatis obtusis quam fertiles duplo v. ultra brevioribus præditæ. Flores ♂: antheræ ovatæ v. ovato-sagittatæ apice obtusæ, basi emarginatæ, post anthesin arcuato-reflexæ, filamentis calyce duplo-triplo longioribus. Rudimentum ovarii longum calycem subæquans apice disciformi-dilatatum 4-lobatum.

HAB. Shikoku: Prov. Tosa, leg. T. MAKINO.

Hondo: Insula Kōzusima; prov. Shinotsuke, in monte Nikko-urayama, anno 1879; prov. Musashi, in tractu Tichibu.

2. ***B. sempervirens* LINN. var. *microphylla* BL.** (Tab. VI. D.)——BLUME, in herb. Lugd.—Bat. ex MIQ. Prol. 292; Hook. f. Fl. Brit. Ind. V. 267.

B. microphylla SEIB. et ZUCC. in Abhandl. Akad. Muench. IV. 2, 142; BAILL. Monogr. Bux. et Styl. 64.

B. japonica β *microphylla* MUELL. ARG. in DC. Prodr.

XVI.-1, 20; MIQ. Prol. Fl. Jap. 292; FRANCH. et SAV. Enum. Pl. Jap. I. 428.

B. sempervirens LINN. *a angustifolia* SIEB. et ZUCC. l.c.

Nom. Jap. *Hime-tsuge*.

Folia 13–20 mm. longa, 3–8 mm. lata, spathulato-lanceolata, lineari-oblonga, obtusa v. subemarginata, basi attenuata, coriacea nitida glabra. Styli carnosi, emarginato-bilobati.

HAB. Prov. Awa, Kominyo-mura, anno 1880; Mama-mura (cult.)

3. **B. Wallichiana** BAILL. (Tab. VI. E.)——BAILL. Mono. Bux. et Styl. 63.

B. sempervirens LINN. var. *liukiensis* MAKINO, in Tokyo Bot. Mag. IX. (1895), 279, et XV. (1901), 169.

Nom. Jap. *Okinawa-tsuge*.

Frutices; rami fusi, ramulis puberulis. Folia opposita, oblongo-ovata, oblonga, obovata, ovata, v. oblanceolata, basi attenuata, emarginata, integra, coriacea, viridia, nitida, subtus pallidiora, 14–3 cm. lata, 3–6 cm. longa cum petiolis puberulis brevibus. Inflorescentiæ axillares, bracteatae; fl. ♀ superiores, fl. ♂ inferiores. Flores ♂: brevissime pedicellati. Sepala 4, membranacea, concava, margine ciliolata, duo exteriora minora late ovata; duo interiora majora, orbicularia, concava, 2½ mm. lata. Rudimentum ovarii inclusum breve apice dilatatum 4-lobatum. Stamina 4, multo exserta; filamenta valida; antheræ angusto-ovatae. Capsulae ovoideae leves, duræ, circ. 1 cm. longæ, stylis persistentibus. Semina oblonga, nigra, nitida.

HAB. Liu-kiu: Insula Okinawa, in monte Kuzi-magiri, leg. Y. TASHIRO, anno 1887; Shuri.



Distributio Specierum in Imperio Japonico.

Species et Varietates.	Yezo.	Hondo. bor.	Hondo. med.	Hondo. aust.	Shi- koku.	Kiu- shiu.	Liu- kiu.	For- mosa.
<i>Securinega flueggeoides</i> MUELL. ARG.			—	—	—	
<i>Flueggea microcarpa</i> BLUME.								—
<i>Phyllanthus Niruri</i> L.			—	—
„ <i>urinaria</i> L.			—	—	—
„ <i>simplex</i> RETZ.								—
„ <i>Matsumuræ</i> sp. nov.			—	—				
„ <i>liukiensis</i> MATSUM.							—	
„ <i>flexuosus</i> MUELL. ARG.				—	—	—		
„ <i>reticulatus</i> POIR.								—
<i>Glochidion lanceolatum</i> sp. nov.								—
„ <i>zeylanicum</i> A. JUSS.								—
„ <i>hirsutum</i> MUELL. ARG.								—
„ <i>bicolor</i> MUELL. ARG.								—
„ <i>obovatum</i> SIEB. et ZUCC.			—	—		—
„ <i>formosanum</i> sp. nov.								—
<i>Breynia accrescens</i> sp. nov.								—
„ <i>rhamnoides</i> MUELL. ARG.						—	—	
„ <i>stipitata</i> MUELL. ARG. var. <i>formosana</i> .								—
<i>Putranjiva Roxburghii</i> WALL.							—	—
<i>Antidesma japonica</i> SIEB. et ZUCC.						—	—	
<i>Bischoffia japonica</i> BLUME.							—	—
<i>Bridelia tomentosa</i> BLUME.								—
<i>Daphniphyllum macropodum</i> MIQ.			—	—				
„ <i>glaucescens</i> BLUME.			—	—	—	—
„ „ „ var. <i>Oldhami</i> HEMSL.								—
„ <i>himalayense</i> MUELL. ARG.								—
<i>Croton Cumingii</i> MUELL. ARG.							—	—
„ <i>Tigilium</i> L.								—
<i>Mercurialis leiocarpa</i> SIEB. et ZUCC.			—	—	...	—	—	
<i>Mallotus moluccanus</i> MUELL. ARG.								—
„ <i>Playfairii</i> HEMSL.								—
„ <i>repandus</i> MUELL. ARG.								—
„ <i>philippinensis</i> MUELL. ARG.							—	—
„ <i>japonicus</i> MUELL. ARG.			—	—	—
„ <i>cochinchinensis</i> LOUR.								—

Species et Varietates.	Yezo.	Hondo. bor.	Hondo. med.	Hondo. aust.	Shi- koku.	Kiu- shiu.	Liu- kiu.	For- mosa.
<i>Alchornea trewioides</i> MUELL. ARG.							—	
<i>Cleidion ulmifolium</i> MUELL. ARG.							—	
<i>Macaranga Tanarius</i> MUELL. ARG.							—	—
<i>Acalypha australis</i> L.			—	—	—	—
„ „ var. <i>lanceolata</i> n. v.								—
<i>Ricinis communis</i> L.			—	—	—	—
<i>Homonoya reparia</i> LOUR.							—	—
<i>Aleurites cordata</i> STEUD.			—	—	—
<i>Excoecaria Agallocha</i> L.							—	—
„ <i>japonica</i> MUELL. ARG.			—	—	—	—	—	
„ <i>crenulata</i> WIGHT.								—
<i>Sapium sebiferum</i> ROXB.			—	—
<i>Euphorbia lathyris</i> L.			—					
„ <i>dendroides</i> L.								—
„ <i>Helioscopia</i> L.			—	—	—	
„ <i>adenochlora</i> MORR. et DECNE.			—					
„ <i>Jolchini</i> BOISS.			—	—	—	
„ <i>pekinensis</i> RUPR.			—	—	—	—		
„ <i>togakusensis</i> sp. nov.			—					
„ <i>orientalis</i> L.								—
„ <i>ebracteata</i> sp. nov.	—	...	—					
„ <i>Sieboldiana</i> MORR. et DECNE.	—	—	—					
„ <i>Esula</i> L.			—	—				
„ <i>Sparmanni</i> Boiss.							—	—
„ <i>pilulifera</i> L.							—	—
„ <i>hypericifolia</i> L.							—	—
„ <i>serrulata</i> REINW.							—	—
„ <i>thymifolia</i> L.							—	—
„ <i>maculata</i> L.			—	—				
„ <i>humifusa</i> WILLD.			—	—	—			
„ <i>microphylla</i> HEYNE.								—
<i>Pachysandra terminalis</i> SIEB. et ZUCC.	—	—	—					
<i>Buxus sempervirens</i> L. var. <i>japonica</i> MAKINO.			—	...	—			
„ <i>sempervirens</i> L. var. <i>microphylla</i> BLUME.					—			
„ <i>Wallichiana</i> . BAILL.							—	

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B. HAYATA.

REVISIO EUPHORBIACEARUM ET BUXACEARUM JAPONICARUM.

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L. *Daphniphyllum himalayense* MUELL. ARG. (p. 34).—1 Fragmentum folii.—2 Fragmentum ramuli, stipulæ videntur.—4 Flos ♂.—3 Idem a dorso visus.—5 Stamina; alium a facie, alium a dorso, alium a latere visum.—6 Glandula et ejus horizontalis sectio. (1, mag. nat.; 2-6, mag. auct.)



R. HAYATA.

REVISIO EUPHORBIACEARUM ET BUXACEARUM JAPONICARUM.

TABULA III.

Explicatio tabulæ III.

Plantæ tabulæ ex speciminibus exsiccatis depictæ.

A. *Bridelia tomentosa* BLUME. (p. 30).—1 Flos ♂.—2 Idem, pars amorta.—3 Stamen alterum a facie, alterum a dorso visum.—4 Flos ♀, pistillum amortum, disci duplicati videntur.—5 Verticalis ejus sectio.—6 Flos ♀, pistillo majori.—7 Fructus.—8 Semen alterum a dorso, alterum a facie visum.—9 Horizontalis seminis sectio.—10 Embryo. (1-6, et 8-10, mag. auct.; 7, mag. nat.)

B. *Croton Cumingii* MUELL. ARG. (p. 36).—1 Fragmentum folii.—2 Facies subtus cum lepidotis.—3 Alabastrum.—4 Idem, sepala amorta, petala videntur.—5 Idem, sepala et petala amorta, stamina videntur.—6 Petalum.—7 Stamen maturum, alterum a facie, alterum a dorso visum.—8 Flos ♀.—9 Ejus Verticalis sectio.—10 Petalum.—11 Lepidotus ovarii.—12 Fructus.—13 Alter coccus, alterum semen. (1, 12, et 13, mag. nat.; 2-11, mag. auct.)

C. *Croton Tiglium* L. (p. 36).—1 Fragmentum folii.—2 Pilus folii.—3 Alabastrum ♂, cum bracteolis.—4 Flos ♂ apertus.—5 Idem, sepala et petala amorta, glandulæ videntur.—6 Stamen alterum a facie, alterum a dorso visum.—7 Flos ♀, cum bracteolis.—8 Pilus ovarii.—9 Fructus.—10 Semen.—11 Ejus horizontalis sectio, albumen videtur.—12 Verticalis albuminis sectio, embryo videtur. (1, 9, 10, et 11, mag. nat.; 2-8, et 12, mag. auct.)

D. *Mercurialis leiocarpa* SIEB. et ZUCC. (p. 38).—1 Fragmentum folii.—2 Flos ♂ apertus.—3 Stamina juniora ; alterum a facie, alterum a dorso visum.—4 Stamina juniora.—5 Stamina matura ; alterum a facie, alterum a dorso visum.—6 Fragmentum inflorescentiæ, cum flore ♀ maturo et alabastro ♂.—7 Flos ♀ immaturus.—8 Fructus.—9 Verticalis cocci sectio, semen et embryo videntur.—10 Semen.—11 Embryo. (1, mag. nat.; 2-11, mag. auct.)

E. *Mallotus moluccanus* MUELL. ARG. (p. 40).—1 Fragmentum folii. mag. nat.—2 Facies subtus cum pilis et glandulis.—3 Glandula, validissime aucta.—4 Apex petioli cum multiglandulis.—5 Stamina : aliud a facie, aliud a dorso a dorso, aliud a latere, aliud supra visum.—6 Fragmentum inflorescentiæ ♀.—7 Flos ♀, pistillum amortum, discus videtur.—8 Verticalis floris ♀ sectio.—9 Fructus.—10 Columella cum semine.—11 Embryo. (1, mag. nat.; 2-11, mag. auct.)

F. *Mallotus Playfairii* HEMSL. (p. 41).—1 Fragmentum folii. mag. nat.—2 Pagina folii supra.—3 Indumentum paginæ subtus visum.—4 Glandula paginæ.—5 Floris ♂ verticalis sectio.—6 Stamina ; alterum a facie, alterum a dorso visum. (2-6, mag. auct.)

G. *Mallotus repandus* MUELL. ARG. (p. 42).—1 Fragmentum folii. mag. nat.—2 Pagina folii, subtus visa, pili et glandulæ videntur.—3 glandula validissime aucta.—4 Alabastrum ♂.—5 Horizontalis ejus sectio.—6 Stamen alterum a facie, alterum a dorso visum.—7 Flos ♀.—8 Verticalis ejus sectio (2-3, mig. auct.)

H. *Mallotus philippinensis* MUELL. ARG. (p. 43).—1 Indumentum folii subtus visum, pili et glandulæ videntur.—2 Pilus validissime auctus.—3 Glandula validissime aucta.—4 Flos ♂.—5 Stamen alterum a facie, alterum a dorso visum.—7 Flos ♀, stigmata a facie visa.—6 Flos ♀, stigmata a latere visa.—8 Fructus. mag. nat.—9 Horizontalis fructus dehiscens sectio. (1-7, mag. auct.)

I. *Mallotus japonicus* MUELL. ARG. (p. 44).—1, 1' Fragmenta foliorum.—2 Pagina subtus visa, pili et glandulæ videntur.—3 Glandula validissime aucta.—4 Flos ♂.—5 Stamen alterum a facie, alterum a dorso, visum.—6 Fragmentum inflorescentiæ ♀.—6' Flos ♀.—7 Fructus alter a facie, alter a latere visus.—8 Horizontalis fructus dehiscens sectio.—9 Verticalis albuminis sectio, embryo videtur.—10 Embryo. (1, 4, 6, et 7, mag. nat.; 2, 3, 5, 9, et 10, mag. auct.)

J. *Mallotus cochinchinensis* LOUR. (p. 45).—1 Fragmentum folii.—2 Pagina folii subtus visa, pili et glandulæ videntur.—3 Glandula validissime aucta.—4 Fragmentum folii basi supra biglandulis.—5 Flos ♂ verticaliter sectus.—6 Stamina : aliud a dorso visum, cetera a facie visa.—7 Fructus. mag. nat.—8 Embryo. (1, 4, et 7, mag. nat.; 2, 3, 5, 6, et 8, mag. auct.)



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REVISIO EUPHORBIACEARUM ET BUXACEARUM JAPONICARUM.

TABULA IV.

Explicatio tabulæ IV.

Plantæ tabulæ ex speciminibus exsiccatis depictæ.

A. *Alchornea treviioides* MUELL. ARG. (p. 47).—1 Fragmentum folii. mag. nat.—2 Fragmentum spicæ cum floribus ♀ et ♂.—3 Alabastrum ♂ a facie visum.—4 Flos ♂ apertus.—5 Idem a tergo visus, sepala amorta, filamenta connata videntur.—6 Stamina; aliud a facie, aliud a latere, aliud a dorso, visum.—7 Pistillum, ovario verticaliter secto, ovula videntur.—8 Sepala.—9 Horizontalis ovarii sectio. (2–8, mag. auct.)

B. *Cleidion ulmifolium* MUELL. ARG. (p. 48).—1 Segmentum folii. mag. nat.—2 Segmentum spicæ ♂.—3 Flos ♂.—4, 5 Stamina. (2–4, mag. auct.)

C. *Macaranga Tanarius* MUELL. ARG. (p. 49).—1 Segmentum folii.—2 Pagina subtus visa, glandulæ videntur.—3 Segmentum paniculæ ♂.—4 Flores ♂, cum bractea.—4' Flores ♂; alius verticaliter sectus.—5 Stamina.—6 Segmentum racemi ♀.—7 Flos ♀. (1, 3, et 6, mag. nat.; 2, 4', 5, et 7, mag. auct.)

D. *Acalypha australis* L. (p. 50).—1 Pistillum cum spica ♂.—2 Fragmentum spicæ ♂.—3 Flos ♂ a facie visus.—4 Fl. ♂ a tergo visus.—5 Flos ♂, sepala amorta.—6 Stamina cum vermiformibus antheris.—7 Pistillum junius.—8 Sepalum.—9 Horizontalis ovarii sectio.—10 Capsula.—11 Semen, caruncula videntur.—12 Albumen.—13 Embryo. (1–13, mag. auct.)

E. *Excœcaria japonica* MUELL. ARG (p. 59).—1 Flores ♂ cum bractea.—2, 3 Flores ♂.—4 Stamen alterum a facie, alterum a dorso visum.—5 Flores ♀.—6 Fructus. mag. nat.—7 Horizontalis fructus dehiscentis sectio.—8 Albumen.—9 Embryo.—10 Diagramma fl. ♂.—11 Diagramma fl. ♀. (1-5, mag. auct.)

F. *Euphorbia Lathyris* L. (p. 64) Planta ex specimine recente depicta.—1 Involucrum cum floribus ♂ et ♀.—2 Verticalis ejus sectio.—3, 4 Stamina.—5 Stamen a latere visum.—6 Glandula.—7 Involucri lobus.—8 Fructus.—9 Coccus.—10 Caruncula subtus visa.—11 Semen cum carunculæ stipiti; caruncula amorta est.—12 Embryo. (1-12, mag. auct.)

G. *Euphorbia Helioscopia* L. (p. 66) Planta ex specimine recente depicta.—1 Involucrum cum floribus ♂ et ♀.—2 Idem verticaliter sectum.—3 Involucrum fissum et explicatum.—4 Bracteola floris ♂.—5 Capsula.—6 Coccus.—7 Semina; alterum a latere, alterum a dorso visum.—8 Albumen.—9 Embryo. (1-9, mag. auct.)

H. *Euphorbia adnoclora* MORR. et DECNE. (p. 67) Planta ex specimine recente depicta.—1 Involucrum cum floribus ♂ et ♀.—2 Idem, verticaliter sectum.—3 Involucrum fissum et explicatum.—4 Ejus fragmentum.—5 Ejus glandula et lobi.—6 Bracteola floris ♂.—7 Stamina; aliud a facie, aliud a dorso, aliud a latere visum.—8 Stamen, anthera dehiscens.—9 Capsula dehiscens.—10 Coccus.—11 Semen a facie visum.—12 Semen a tergo visum.—13 Verticalis abalbuminis sectio, embryo videtur. (1-8, et 12-14, mag. auct.; 8 et 9, mag. nat.)

I. *Euphorbia ebracteolata* sp. nov. (p. 71).—1 Involucrum cum floribus ♂ et ♀.—2 Involucrum fissum et explicatum.—3 Fragmentum involucri extus visum.—4 Flos ♀.—5 Fructus. mag. nat. (1-4, mag. auct.)

J. *Euphorbia pekinensis* RUPR. (p. 68).—1 Involucrum cum floribus ♂ et ♀.—2 Involucrum fissum et explicatum.—3 Ejus fragmentum cum glandula et bracteola.—4 Glandula extus visa.—4' Glandula a facie visa.—6 Stamina.—7 Pistillum a facie visum.—8 Fructus.—9 Semen. (1-9, mag. auct.)



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TABULA V.

Explicatio tabulæ V.

Plantæ tabulæ ex speciminibus exsiccatis depictæ.

A. *Euphorbia Sparmanni* Boiss. (p. 73).—1 Fragmentum rami, mag. nat.—2 Folium. mag. nat.—3 Cyme.—4, 5 Involucri.—6 Involucrum fissum et explicatum.—7 Bracteola.—8 Stamina.—9 Capsula.—10 Semina; a, a latere, b, a facie, c, supra visum.—11 Embryo. (3-11, mag. auct.)

B. *Euphorbia pilulifera* L. (p. 74).—Fragmentum rami. mag. nat.—2 Folium. mag. nat.—3 Cyme. validius auctus.—4 Involucri cum floribus ♀.—5 Involucrum fissum et explicatum.—6 Glandula cum appendiculo.—7 Bracteola.—8 Capsula.—9 Semen.—10 Embryo. (3-10, mag. auct.)

C. *Euphorbia hypericifolia* L. (p. 75).—1 Fragmentum rami. mag. nat.—2 Folium. mag. nat.—3 Cyme.—4 Idem validius auctus.—5 Involucrum fissus et explicatum a exteriore visum.—6 Idem a interiore visum.—7 Bracteola.—8 Capsula.—9 Semen.—11 Semen albume.—12 Embryo. (3-12, mag. auct.)

D. *Euphorbia serrulata* REINW. (p. 76).—1 Fragmentum rami.—2 Cyme.—3 Involucrum cum flori ♀.—4 Involucrum fissum et explicatum.—5 Bracteola.—6 Capsula.—7 Semen.—8 Embryo. (2-8, mag. auct.)

E. *Euphorbia thymifolia* L. (p. 77).—1 Fragmentum rami mag. nat.—2 Idem cum floribus, mag. nat.—3 Fragmentum ramuli.—4 Involucri.—5 Idem fissum et explicatum.—6 Fragmentum involucri.—7 Bracteolæ.—8 Capsula.—9 Semen.—10 Embryo. (3-10, mag. auct.)

F. *Euphorbia maculata* L. (p. 78).—1 Fragmentum rami mag. nat.—2 Fragmentum ramuli.—3 Involucrum.—4 Involucrum fissum et explicatum.—5 Fragmentum involucri.—6 Verticalis glandulæ et appendiculi sectio.—7 Bracteolæ.—8 Flos ♀ maturus.—9 Capsula.—10 Semen.—11 Embryo. (2-11, mag. auct.)

G. *Euphorbia humifusa* WILLD. (p. 78).—1 Fragmentum rami. mag. nat.—2 Fragmentum ramuli.—3 Involucrum cum floris ♀.—4 Involucrum fissum et explicatum.—5 Glandulæ et appendiculi.—6 Capsula.—7 Semen.—8 Ejus horizontalis sectio.—9 Albumen.—10 Embryo. (2-10, mag. auct.)

H. *Euphorbia microphylla* HEYNE. (p. 79).—1 Fragmentum rami. mag. nat. —2 Fragmentum ramuli.—3 Involucrum junius.—4 Involucrum fissum et explicatum.—5 Fragmentum ejus cum lobis et bracteolis.—6 Stamina.—7 Involucrum maturum.—8 Capsula.—9 Semen.—10 Ejus horizontalis sectio.—11 Embryo. (2-11, mag. auct.)



B. HAYATA.

REVISIO EUPHORBIACEARUM ET BUXACEARUM JAPONICARUM.

TABULA VI.

Explicatio tabulæ VI.

Plantæ tabulæ ex speciminibus exsiccatis depictæ.

A. *Euphorbia togakusensis* sp. nov. (p. 69).—1 Involucrum cum floribus ♀ et ♂.—2 Idem a latere visum.—3 Involucrum fissum et explicatum.—4 Bracteola.—5 Pistillum a facie visum, styli amorti.—6 Fructus. mag. nat.—7 Fructus.—8 Semen a latere visum.—9 Semen a tergo visum. (1–5, et 7–9 mag. auct.)

B. *Euphorbia Sieboldiana* MORR. et DECNE. (p. 71). Planta ex specimine recente depicta.—1 Involucrum cum floribus ♂ et ♀.—2 Involucrum verticaliter sectum.—3 Involucrum fissum et explicatum.—4 Fragmentum involucri.—5 Stamina dehiscencia; alterum a dorso, alterum a facie visum.—6 Stamina; alius a facie, alius a latere, alius a dorso, visum.—7 Fructus.—8 Semen alaterum a facie, alterum a dorso visum. (1–8 mag. auct.)

C. *Buxus sempervirens* L. var. *japonica* MAKINO. (p. 82) Planta ex specimine recente depicta.—1 Fragmentum rami. mag. nat.—2 Axillæ foliorum oppositorum a facie visæ.—3 Idem a tergo visæ.—4 Fasciculus ♂.—5 Flos ♂.—6 Idem verticaliter sectus.—7 Stamina; aliud a dorso, aliud a facie, aliud a latere, visum.—8 Stamen anthera dehiscente.—9 Rudimentum ovarii alterum a facie, alterum a dorso, visum.—10 Flos ♀.—11 Pistillum validius auctum.—12 Horizontalis capsulæ dehiscantis sectio.—13 Semen.—14 Embryo. (2–11, mag. auct.)

D. *Buxus sempervirens* L. var. *microphylla* BL. (p. 83)—1 Fragmentum. rami. mag. nat.—2 Axillæ foliorum oppositorum a facie visæ.—3 Idem a dorso visæ.—4 Flos ♂.—5 Flos ♂, sepala amorta, rudimentum ovarii et stamina videntur (2–4 mag. auct.)

E. *Buxus Wallichiana* BAILL. (p. 84).—1 Fragmentum rami. mag. nat.—2 Flos ♂.—3 Idem verticaliter sectus.—4 Rudimentum ovarii. (2–6, mag. auct.)

F. *Pachysandra terminalis* SIEB. et ZUCC. (p. 81).—1 Folium. mag. nat.—2 Spica cum floribus ♀ et ♂. mag. nat.—3 Flos ♂.—4 Idem verticaliter sectus, stamina amorta, rudimentum ovarii videntur.—5 Stamina.—6, 7 Sepala.—8 Rudimentum ovarii.—9 Flos ♀ cum bracteolis.—10 Pistillum.—11 Horizontalis ovarii sectio.—12 Fructus. mag. nat.—13 Semen.—14 Ejus horizontalis sectio.—15 Embryo. (3–11, et 13–15, mag. auct.)



The Gephyrea of Japan.

By

Iwaji Ikeda, *Rigakushi*.

With 4 plates

Only four species of Gephyreans, so far as I am aware, have hitherto been recorded from Japan, viz., *Phymosoma japonicum* GRUBE, *Dendrostoma blandum* SEL. & DE MAN, *Phascolion lucifugax* SEL. & DE MAN and *Echiurus uncinatus* v. DRASCHE. From my studies of the group during several years, 34 more species have become known to me, thus giving in all 38 species to the Gephyrean fauna of Japan as at present known. But of the four previously known species mentioned above, *Phascolion lucifugax* has, till the present day, remained wholly missing in my collection.

In this paper I propose to give short descriptions of, and comments upon, all the 37 species directly known to me.

Of the said 37 species, 26 belong to the Sipunculoids under 7 genera and 11 to the Echiuroids under 3 genera. Again, 24 species of them seem to be new; the remaining 13 species I have identified with those which other investigators have described from different parts of the world. It should be mentioned that

this identification could in several cases be made only with a greater or less degree of doubt as to its correctness. This is due, I think, mainly to the excessive conciseness of terms in which most of the old species (especially in the Echiuroidea) were described.

I have not deemed it necessary, for the present at least, to create a new genus for the reception of any of the new species, although the thought frequently suggested itself to my mind that some of the forms, e.g. *Thalassema tænioides* n. sp., might well be made the type of a distinct genus.

At the end of the paper will be given a key to all the species treated of, which may help students of the same field in the task of identification.

For the purpose of obtaining my material I have made frequent visits to the Misaki Marine Laboratory. Further I may mention that on a collecting trip to the Island of Amani-Ōshima (Province of Satsuma) and the Islands of Riukiu in 1901, and on others to the Province of Aomori in 1900 and to Gogoshima (Province of Iyo) in 1903, special attention was paid to the Gephyrean fauna.

To a number of friends, whose names will be mentioned in the proper places, I am indebted for gifts of several valuable specimens, some of which I should otherwise have been unable to obtain.

SIPUNCULOIDEA.

Genus PHASCOLOSOMA.**PHASCOLOSOMA NIGRUM**, N. SP.

(Figs. 1, 25-27).

This new species (Fig. 1) is of a moderate size, the total length being about 10 *cm.* The introvert is nearly $2\frac{1}{2}$ times as long as the body proper, than which it is slightly narrower. The posterior end of the body is always conically pointed. The body in life is coiled more or less in a spiral-like manner. The greater part of the body is dark gray or bluish-black in color, except the tentacular basis of the introvert where it is light brown. The tentacles, of a clear violet color, are filamentous and very numerous, arranged in 30-32 longitudinal rows. When viewed from above, the oral ends of every set of two tentacular rows are joined by a U-shaped ridge, the mouth being thus surrounded by 15 or 16 of such ridges with radial grooves between. Small skin-bodies are very abundant and are distributed over the entire surface of the introvert and of the body proper. They are largest on the introvert-basis and on the posterior end of the body, in both of which parts they appear as low papillæ of 0.1 *mm.* diameter and 0.05 *mm.* height (Fig. 25). Each papilla is an elliptical and slightly elevated granular disc of a brownish black color; in its

centre there is a yellow and radially striated area bearing the opening of the subdermal gland. On the introvert these papillæ become smaller and smaller anteriorly, but without undergoing a noticeable change in height (Fig. 26). They show no striated central area, the entire surface being finely granulated. Neither hook nor spine is present on the introvert.

The inner surface of the body-wall is remarkably smooth and shiny. The longitudinal muscles in the same are continuous. The retractor muscles are only two in number, forming a ventral pair (Fig. 27, *vm*). They originate at the beginning of the posterior third of the body proper, close to the nerve-cord (*n*). In the anterior parts they are fused together into one flat band, running in contact with the long œsophagus (*oe*) on the ventral side. Along the dorsal side of the latter runs the dorsal vessel, the posterior parts of which are beset with numerous but short contractile villi (*cv*). The long intestinal convolution (*ic*) consists of about 20–25 double spirals, closely twisted around the spindle-muscle which posteriorly does not pass out of the spirals for fixation to the body-wall. Only one, but very long, fixing muscle (*fm*) extends between the posterior end of the œsophagus and a point in the body-wall situated a short distance in front of the origin of the left retractor muscle on the left hand side. The rectal intestine (*rc*) carries at its beginning a small blind sac, the rectal gland (*rg*). The rectum is fixed to the body-wall by two broad wing-muscles (*wm*). The segmental organs (*so*) are of a conspicuous length; they are free from the body-wall except at the external apertures which are situated a certain distance in front of the anus. They are colored with a deep reddish brown pigment. The anus is indicated on the outside by a prominent papilla. The sexual organs are, as is usually the case,

two slender wavy bands (*sv*), developed across the points of origin of the retractor muscles (*vm*).

The present species agrees in some points with *Phascolosoma semperi* SEL. & DE MAN, as described by SELENKA (28), but it can be readily distinguished from that species by the characteristic dermal papillæ. The same distinction may be pointed out as obtaining between the present species and *Phascolosoma fimbriatum* SLUITER (37).

Habitat: The species is one of the commonest Sipunculoids met with in the vicinity of the Misaki Marine Laboratory; it is also common along the coasts of the Tokyo Bay and of the Inland Sea. It lives in shallow muddy bottom, especially in small inlets into which fresh-water finds egress.

PHASCOLOSOMA JAPONICUM, N. SP.

(Figs. 2, 28 & 29).

The length of the body proper is about 5 *cm.* on an average, the introvert being about as long as two-thirds of the body proper (Fig. 2); the two regions pass over into each other without a distinct demarkation. The maximum width of the body proper is about 7 *mm.* The body-wall is thin and of a brownish yellow color, of a deeper brown in male worms than in female. To the naked eye the skin-surface appears quite smooth, but under certain magnification there are seen numerous skin-bodies of elliptical shape, thickly distributed (Fig. 28). These bodies are flat, not covered with chitinous plates, and are somewhat transparent; a

group of subdermal glands, situated beneath the skin-body, are seen to open to the exterior by a small common pore (see *p*) at the centre. The papillæ are of nearly the same size throughout the whole surface of the body, viz., 0.09–0.06 *mm.* in diameter. No hook or spine is present. The tentacles are filamentous and tolerably numerous, and are arranged in about 12–14 longitudinal rows around the oral disc, each row consisting of about five tentacles. The rows, in sets of two, are united at the oral end by U-shaped elevations as in the preceding species. Two dark brown eye-spots are present on the ganglion or brain (*g*, Fig. 29).

The longitudinal muscles of the body-wall are uniformly distributed. The inner surface of the wall is smooth and shiny like a pearl. There are present two pairs of retractor muscles, of which the ventral pair (*vm*) originate at about the middle of the body proper close to the nerve-cord (*n*), while the dorsal pair (*dm*) arise from a region a short distance behind the anus (*a*). The œsophagus (*oe*) is fixed by thin membranaceous muscles and is accompanied dorsally by the dorsal vessel (*dv*), which posteriorly reaches down to the beginning of the intestinal convolution (*ic*). This vessel develops no contractile villi. The intestinal convolution is made up of 17–23 double spirals and is traversed throughout by the spindle-muscle which at the posterior end is not fixed to the body-wall. There exist in all three fixing muscles, one on the right and two on the left side of the nerve-cord (see *fm*, Fig. 29). One on each side is attached to the beginning of the rectum, while the unpaired and asymmetrical one on the left side is fixed to the posterior terminal portion of the œsophagus. A large blind rectal gland (*rg*) is attached to the middle part of the rectum. The anterior portion of the rectum is fixed by well developed wing-muscles (*wm*). The two segmental organs (*so*),

the external apertures of which lie slightly in front of the anus, are tolerably long, corresponding in length to nearly one half of the body proper. They are of a deep brownish color and are entirely free from the body-wall except at the anterior end. The sexual organs (*sz*) are developed as two narrow transverse bands placed across the bases of the ventral retractor muscles.

Habitat: This species is common along the coasts of the Tokyo and Sagami Bays. It occurs very abundantly in shallow waters near the Misaki Marine Laboratory. The animals live in clean sand, mostly in narrow fissures of rocks. No specimens have thus far been obtained at any other locality than those mentioned above.

PHASCOLOSOMA MISAKIANUM, N. SP.

(Figs. 3, 30-33).

This species is small and slender. The total length of the animal with the introvert wholly protruded, measures about 5 *cm.*, the thickest part of the body proper rarely exceeding 2 *mm.* in width. The introvert corresponds in length to about four-fifths of the total length. The skin is smooth, thin and somewhat transparent; it is of a yellowish pink color (Fig. 3). Under high magnification there can be detected numberless small papillary bodies distributed all over the body-surface. In the posterior region of the body, where these bodies are most closely aggregated, they measure 0.03 *mm.* in both height and diameter. Here they take the shape of a small rounded cone, on the summit of which

numerous small chitinous granules of a yellow color are so arranged as to form a ring surrounding the external aperture of the subdermal gland (see Figs. 30 *a* and *b*). In the middle region of the body proper, the papillæ are quite flat, elliptical in form and much larger than in the posterior region. The chitinous granules of such papillæ are much smaller than those referred to above. In the introvert, the papillæ are very slightly elevated (nearly 0.015 *mm.* in height) and so small that they might appropriately be called tubular with “Mündungskörper” (Fig. 31). The introvert carries about 60 ring-rows of hooks of a small size. The hooks in a way alternate in position with the tubular papillæ, there being about five of the former between every two of the latter. The hooks are 0.025 *mm.* high, light yellow in color, and are provided with a sharp and strongly curved apical tooth and 4–5 short accessory teeth (Fig. 32). The accessory teeth gradually decrease in number in the hooks forming the more posterior rings finally to disappear altogether. The tentacles are filamentous and nearly always 8 in number, surrounding the oral aperture. The eye-spots are seen as two small, brown specks lying on the lateral corners of the ganglion.

The longitudinal musculature of the body-wall is continuous. Of the two pairs of the retractor muscles, which are all slender, the ventral pair (*vm*, Fig. 33) originate at the middle of the body proper, while the dorsal (*dm*) do so far more anteriorly. The anus lies at a position nearly midway between the origins of the two pairs of muscles. A feature peculiar to this species is presented by the sexual organs (*sx*). These are narrow band-like structures situated at a considerable distance behind the origin of the ventral retractor muscles. The dorsal vessel (*dv*) is very short, extending posteriorly for only a few millimeters beyond

the ganglion, and is not provided with contractile villi. The intestinal convolution (*ic*) is formed of 6-10 double spirals which are more or less irregularly twisted around the fine spindle-muscle (*sm*). The latter is fixed to the body-wall at both its anterior and posterior ends. Its anterior end is at a considerable distance anteriorly from the anus. There is only one fixing muscle (*fm*), connecting the hind end of the œsophagus (near the commencement of the convolution) with the body-wall on the left side of the nerve-cord and a short distance in front of the origin of the ventral retractor muscles. No blind diverticulum is present on the rectum. The latter is supplied with wing-muscles (*wm*). The segmental organs (*so*) exhibit a peculiar structure unknown in other Sipunculids. Each of them consists of two long lobes equal in size and shape, the one being directed anteriorly and the other posteriorly. The two lobes are directly continuous with each other. At their boundary lies the external aperture, the inner aperture or the funnel being found at the basis of the anterior lobe. The organs have a reddish yellow color. Their wall is very thin.

Habitat: The animals are discovered under sea-weeds covering a tufaceous sandstone between the tide-marks. They have hitherto been collected only on the shores near the Misaki Marine Laboratory, where however they are rare.

PHASCOLOSOMA OKINOSEANUM, N. SP.

(Figs. 4, 34-38).

In March, 1901, a single specimen of the species here described as new under the above name was dredged at a depth of

400 *hiro** (near the Okinosé bank) in the Sagami Sea. The following description is based on that specimen which is preserved in formalin.

The worm is of a moderate size and of a brownish yellow color. The body proper is about 4.5 *cm.* in length and 7 *mm.* in maximum width, it being posteriorly narrowed into a small and slender tail-process (Fig. 4). The introvert, which had partly retracted, is apparently about as long as the body proper, but much narrower, averaging 3 *mm.* in width. The skin-surface appears smooth to the naked eye, but under certain magnification numberless prominent papillæ may be discovered. They are largest and tallest in the posterior region of the body, reaching up to 0.08 *mm.* in height and 0.03 *mm.* in thickness (Fig. 34). They are of a brownish yellow color and are composed of very small, closely aggregated, chitinous granules. The papillæ become gradually shorter and shorter towards the base of the introvert, in which parts they are represented by flat bodies separated from one another by irregular narrow grooves (Fig. 35). The latter form a sort of mesh-work, in the meshes of which is contained a papillary body. Each body is formed of a small granular ring of a brownish yellow color and of a colorless transparent central area containing the small external aperture of the subdermal gland. The granular ring measures about 0.03 *mm.* in diameter. Towards the middle and anterior parts of the introvert, the papillæ again become nearly as large and long as in the posterior parts of the body. In the regions of the introvert mentioned, the chitinous layer of the skin shows fine striations intersecting at right angles. No hook or spine, nor eye-spot, is present. Peculiar structures are

* 1 *hiro*=about 5 feet.

found on the skin-surface of the body proper; we have here to do with tolerably large, elongated sacs with a thin, colorless and transparent wall. Fig. 36 represents one of the structures greatly magnified. The organ is hollow; its cavity communicates with the body-cavity by a small aperture which is situated just at the basis of the organ and is perfectly round in contour (Fig. 37). As Fig. 37 shows, the wall contains a number of longitudinal muscle-fibers (*mf*) running parallel to one another. A closer microscopical examination shows that most of these muscle-fibers are proximally continuous with the circular muscles of the body-wall. From the structure and the relation of the organs to the body-cavity, it seems very probable that they serve as the respiratory apparatus. They are found here and there all over the surface of the body proper, but are most numerous in the posterior region.

The longitudinal muscles are everywhere continuous. The inner surface of the body-wall is of a shiny appearance. There exist two pairs of the retractor muscles, which are fairly long and very slender. The ventral pair (*vm*, Fig. 38) spring from the posterior border of the anterior one-third of the body proper, while the dorsal pair arise about 7 *cm.* in front of that border. The sexual organs (*sx*) are developed as two narrow wavy bands attached to the base of the ventral retractor muscles (*vm*). The intestinal convolution (*ic*) is long and conspicuous, consisting of about 20 double spirals closely twisted around the spindle-muscle (*sm*) which posteriorly is not fixed to the body-wall. Three fixing muscles (*fm*) are present. One of them originates inside the base of the left ventral muscle and ends at the posterior free part of the œsophagus. The other two are rooted each on one side of the nerve-cord and are attached to the beginning of the rectal

intestine. Just opposite these two points of attachment, there is found a small roundish rectal diverticulum. The segmental organs (*so*) are relatively short and small, measuring about 10 *mm.* in length. They are transparent and almost colorless tubes, unaccompanied by a mesentery. Their external openings are situated nearly on the same level as the anus (*a*). The presence of the dorsal vessel could not be ascertained. The tentacles, surrounding the mouth, are filamentous and very numerous.

PHASCOLOSOMA OWSTONI, N. SP.

(Figs. 5, 39-44).

The single specimen (Fig. 5), on which this species is based, was dredged in 1899 by Mr. Owston of Yokohama from a depth of 180 *hiro* in the Uraga Channel. It has been preserved in formalin.

The total length of the animal is 8 *cm.*, one-fourth of which appertains to the introvert. The posterior half of the body proper is wider than the anterior and measure 8-10 *mm.* across. The entire introvert is nearly of the same thickness as the anterior and narrower part of the body proper. The ground color of the skin is a light blue, suffused with pink; the middle portion of the introvert is tinted a deep brown, and the posterior portion of the body-proper a light brown. The body-wall is in the body proper relatively thin, smooth on the external surface and more or less transparent, while in the introvert it is thick, opaque and has a closely wrinkled surface. All over the sur-

face of the body there are sparsely distributed papillæ. In the posterior region of the body proper, these are very large and long, measuring 0.125 *mm.* in height and 0.054 *mm.* in thickness. Each papilla is covered with a number of small chitinous granules of a reddish brown color; the apex is bored through by a small pore leading into the subdermal gland (Fig. 39). Towards the introvert-basis, the papillæ become gradually shorter and shorter, until in that region they are very short and assume the shape of a round disc of a yellowish color (Fig. 40). Fine radial striation is found in the central chitinous plate containing the aperture of the subdermal gland. The more anteriorly situated papillæ of the introvert are once again more prominent and those close to the hooked region have the form of a moderately tall (0.04–0.07 *mm.*), round-pointed process covered with small chitinous granules of a yellowish color (Fig. 41). The hooks (Fig. 42), without being arranged in ring-rows, are extensively distributed behind the tentacular region of the introvert. They are 0.22–0.13 *mm.* high, slender and almost straight; and of a brownish yellow color.

The longitudinal muscles are quite continuous and the inner surface of the body-wall is shiny like a pearl. The retractor muscles (*dm*, *vm*, Fig. 43) are three in number, the right ventral retractor being absent. The left ventral retractor (*vm*) arises at the beginning of the middle third of the body proper, close to the nerve-cord, while the two dorsal retractors (*dm*) originate immediately behind the anus (*a*). The two muscles of the left side are entirely coalesced into one band, and anteriorly are again joined to the dorsal retractor of the right side. In spite of the absence of the right ventral retractor, the sexual organs (*sx*) are symmetrically developed as two slender transverse

bands stretching along the basal line of the left retractor, as well as in the corresponding position on the right side. The œsophagus (*œ*) is connected by a membranous muscle with the inner side of the left ventral muscle. The dorsal vessel (*dv*) runs along the entire dorsal side of the œsophagus; it is not provided with contractile villi. The intestinal convolution (*ic*) consists of about 30 double spirals around the spindle-muscle (*sm*). The latter does not posteriorly pass out of the spirals to insert itself in the body-wall. The small diverticulum attached to the beginning of the rectum is comparatively short. Two fine fixing muscles (*fm*, Fig. 43), are attached to the fourth spiral of the convolution; they are rooted on the body-wall at points lying just behind the bases of the dorsal retractor muscles. The segmental organs (*so*), of a deep reddish brown color, are of a moderate size. Their external apertures are situated on the same level as the anus (*a*). Tentacles are tolerably numerous and encircle the mouth in a ring. No eye-spot can be detected on the ganglion.

A peculiar reticular structure (*rt*, Fig. 43) is found lining the inner surface of the body-wall in a zone bounded anteriorly by a line joining the external apertures of the segmental organs and posteriorly by a line running midway between the roots of the dorsal and ventral retractor muscles. It appears as an irregular, small-meshed network of trabeculæ, forming a layer over the region indicated. One small portion of the structure is shown in Fig. 44, as seen in surface view under a low magnifying power. Examined on sections, the trabeculæ are seen to be composed of very fine connective-tissue fibers in bundles and of a few muscle-fibers; further it can be made out that the reticular layer is joined to the body-wall by numerous short

bridges which mostly arise from the nodal points of the reticulum. It scarcely needs to be pointed out that the bridges as well as the trabeculæ are covered by the peritoneum. I am at present quite at a loss to explain the physiological significance of the structure. Possibly it is nothing but a certain pathological product.

Genus PHASCOLION.

PHASCOLION RECTUS, N. SP.

(Figs. 45–49).

This new species is based on a single specimen which was obtained, September 1903, from a depth of 400 *hiro* in the Sagami Bay by means of the long-line (Dabonawa). It has been carefully preserved in alcohol.

The worm inhabits the dead shell of a *Dentalium*, the introvert partially protruding out of the larger aperture. The body not being cemented to the shell lies free. The entire length of the worm is about 35 *mm.*, nearly one-third of which constitutes the partly retracted introvert (Fig. 45). The body proper is nearly straight, gently swollen in the middle where it measures about 2 *mm.* across, while the introvert is relatively thick and about 1 *mm.* broad. The skin is of a grayish yellow

color, more deeply yellow in the middle portion of the body proper. The greater part of the body-surface appears nearly smooth to the naked eye, except on the introvert-basis which is rough on account of the presence of tall papillæ and prominent chitinous folds. Under the microscope, it is seen that the apparently smooth part of the surface is beset with skin-papillæ which vary much in shape and size in different portions of the body. In the anterior region of the introvert, the papillæ are very small, transparent, oval bodies, measuring 0.025 *mm.* in height and 0.014 *mm.* in basal diameter. From that region posteriorly, they become somewhat larger and taller, but less closely arranged, and in the middle parts of the introvert they measure about 0.028 *mm.* in height and 0.02 *mm.* in maximum breadth (Fig. 46). On the introvert-basis, the papillæ are rather prominent, showing a club-like shape and measuring about 0.1 *mm.* in height and 0.05 *mm.* in thickness in the broadest part. They have a thick wall, are yellow in color and are perforated by a narrow and likewise club-shaped canal which proximally communicates by a small pore with the cavity of the subdermal gland (Fig. 47). The minute external aperture on the apex of the papilla can scarcely be brought into view. Intermixed with the papillæ are present large, irregularly shaped thickenings of the chitin (see Fig. 47); these appear finely granulated and are of a deep brown color. In the anal region, the papillæ abruptly become short (0.04 *mm.* high) and exhibit a conical form with a basal diameter of 0.046 *mm.* on an average. The apex of such a papilla is occupied by a small mamelon-like body which is pierced through by the papillary canal. Most of these papillæ are situated amongst closely set, large and irregular chitinous thickenings of coarsely granular appearance

and of a deep brown color. Behind the anal region, the papillæ become gradually smaller until in the middle region of the body proper they acquire the form of an almost flat body, measuring 0.02–0.03 *mm.* across at base (Fig. 48). Structurally these flattened papillæ agree with those of the anal region. The skin-surface here also is covered with small chitinous thickenings of various forms and sizes peculiar to this region (see the above figure). At the posterior end of the body the papillæ are once again of a somewhat conspicuous size: here they measure on an average 0.05 *mm.* in height and 0.10 *mm.* in diameter. These, in both their external and internal structure, are quite similar to those found in the middle region of the introvert. No hook or any spiny structure is present on the introvert.

The longitudinal musculature forms a continuous sheath. Only a single and very slender retractor muscle (*rm*, Fig. 49) springs with two short roots from the posterior end of the body. The intestinal convolution consists of about 20 irregularly twisted spirals and is not accompanied by a spindle-muscle. The intestinal spirals are joined to the body-wall by means of four fine fixing muscles (*fm*), two of which are attached to the beginning and the two others near the posterior end of the convolution. The dorsal vessel is about 15 *mm.* long; it is not provided with contractile villi. The segmental organ (*so*) is situated immediately behind the anus as a single elongate sac lying on the right side of the nerve-cord; it is unaccompanied by a mesentery. No eye-spot is found on the ganglion. The tentacles, about 10 in number, are filamentous.

Phascolion rectus agrees with *Phascolion manceps* SEL. & DE MAN, in wanting the "Haftpapillen" and the hooks and

also in having only one retractor muscle, but differs from it, amongst other less important points, in the shape and structure of the papillæ, in the absence of contractile villi on the dorsal vessel and in the position of the anus in relation to the introvert.

PHASCOLION ARTIFICIOSUS, N. SP.

(Figs. 6, 50-55).

Two specimens of the new species here described under the above designation, were collected, July 1903, from a depth of 400 *hiro* in the Sagami Bay. They were both occupying small Gastropod shells. One of them was observed by me in the fresh state and is shown in Fig. 6, enlarged about 10 times.

The aperture of the dead shell inhabited by the worm is plugged with a conical mass of cemented sand having at the apex a pore, out of which the introvert of the worm is partly extruded (Fig. 50). When extracted from the shell, the worm-body is found to be spirally twisted in accommodation to the spiral of the shell. The skin is of a bluish gray (in the fresh state), but bluish black on the closely set papillæ. The body proper is about 1.5 *cm.* long and 3.-3.5 *mm.* thick, while the introvert is about half as long and somewhat narrower (2 *mm.* wide). The papillæ are closely distributed over the entire surface, and vary much in size and shape in different parts of the body. The largest are found in a narrow zone around the middle of the posterior half of the body proper. Here they are of a low conical shape and appear like the so-called "Haft-

papillen" (Fig. 51). The dark-colored apical parts of these papillæ are more or less laterally compressed so as to be flattened. The larger ones measure 0.1–0.2 *mm.* in basal diameter and 0.8–0.15 *mm.* in height. In the remaining regions of the body proper, except at its very anterior end, the papillæ are in general very much smaller and of a bluntly apexed conical shape. In the middle region, the papillæ commonly do not exceed 0.05 *mm.* in basal diameter and in length. In the posterior end they are somewhat larger, measuring 0.1 *mm.* in average length, and take the shape of a pear-shaped sac with a pointed apex (Fig. 53, Pl. III). In the extreme anterior region, the papillæ are of a shape quite different from those of all other regions. Here they are no longer conical, but are represented by finger-like processes of about 0.07 *mm.* height and 0.04 *mm.* thickness (Fig. 54). The chitinous wall of such a papilla is, especially on the apex, thick and of a yellowish brown color. On the introvert-basis, there again appear conical papillæ similar to those of the body proper. They gradually decrease in size towards the introvert-tip. Fig. 52 represents some papillæ from the middle region of the introvert; here they are seen as transparent, thin-walled processes, 0.04–0.07 *mm.* high and conical in shape but with the apex rounded. No hook or spine can be found on the introvert. The tentacles are simple and not numerous, probably 10 in number.

The longitudinal muscles form a continuous sheet. There are two retractor muscles, one of which is very small and the other (the ventral?) relatively large. The latter arises with two short roots from near the posterior end of the body (*rm* and *rm'*, Fig. 55). The intestinal convolution (*ic*) consists of a few irregular spirals unaccompanied by muscles of any sort. There

is a single segmental organ (*so*) situated on the right side of, and close to, the nerve-cord (*n*). It represents an elongate sac, arising freely from the body-wall.

This species seems to be most closely allied to *Phascolion lucifugax* SEL. & DE MAN, a young specimen of which is said to have been obtained by HILGENDORF in this country. The two species resemble each other especially in having large papillæ in a zone around the middle region of the body proper. But the present species certainly differs from *Phascolion lucifugax* in possessing differently shaped papillæ and in being devoid of hooks on the introvert.

Genus PHYMOSOMA.

PHYMOSOMA SCOLOPS, SEL. & DE MAN.

SELENKA, (28), 1883, *p.* 75.

From SELENKA'S description the specific character of this species may be summed up as follows :

Entire body-length 4 *cm.* on an average. Color reddish brown, often yellowish brown. Introvert bears on the dorsal side numerous pigmented bands of a reddish brown or brownish black color. Papillæ black, tolerably large, but little elevated in the middle region of the body proper ; they consist of brown plates which become gradually smaller towards the peripheral

border. On the introvert-basis and the posterior end of body, the papillæ are conspicuously large and elevated. Hooks about 0.07 *mm.* high, provided with two sharp teeth at the apex and with warts ("Runzeln") at the base; hook-rows about 15-17 in number, between them small hook-papillæ ("Hakenpapillen"). Eye-spots distinct. Tentacles, about 12, arranged in a semicircle above the mouth.

Longitudinal muscles 20-21, rarely anastomosing. Four retractor muscles arising from the middle of the body-proper: the dorsal pair from the 1st-2nd and the ventral from the 5th-6th longitudinal muscles. The intestinal convolution consists of 12-14 spirals, and has a fine spindle-muscle fixed at both ends. The one fixing muscle present is bifurcated towards the intestinal attachment. The segmental organs are half as long as the body proper; the anterior third or fourth of their total length is fixed by a mesentery to the body-wall.

In Japan this species has been collected from the Hokkaido in the north to the Riukiu Islands in the south. As in many other cosmopolitan forms, the species shows remarkable variations, especially in color, according to different surrounding conditions. Specimens from the Riukiu (Loo-choo) Islands and the Ogasawara Islands exhibit all the essential characters described by SELENKA (28) and other authors,—as, for instance, the black crescent-shaped markings on the introvert, papillæ and hooks of the same form and size, &c. Those from the main island of Japan are in several respects slightly different from the above mentioned form. Thus, the individuals living among Ascidian colonies or eroded tufaceous sandstone, show an extremely wide range of variation with regard to the general color of the body and the size and color of the

papillæ. The specimens I collected on the shores of the Aomori Bay, are entirely devoid of the characteristic markings on the introvert, while the skin-papillæ are in general unusually tall. A form similar to the above is also frequently obtained on the shores of Misaki.

PHYMOSOMA JAPONICUM, GRUBE.

SELENKA, (28), 1883, *p.* 76.

The main features of this species are embodied in the following extract from SELENKA's description :

Body proper of larger specimens, about 5 *cm.* in length ; twice as long as introvert. Color, gray or grayish brown. Papillæ visible as reddish brown specks ; they are formed of polygonal plates arranged in concentric circles. About 25–30 hook-rows, —in the younger individuals, sometimes even as many as 100, —are present on the introvert. Hooks 0.07 *mm.* long, very flat laterally, provided with two sharp teeth at apex, and with warts (“Runzeln”) at base. Tentacles, about 28 in number. Two brown eye-spots present on the ganglion.

Longitudinal muscles are divided into about 30, frequently anastomosing bundles. Four retractor muscles arise from the middle one-third of the body proper, the dorsal pair being rooted in front of the ventral pair. Dorsal vessel tolerably long, without contractile villi. Intestinal convolution consists of 10–12 double spirals, traversed by a spindle muscle fixed at both ends to the body-wall. A single fixing muscle is attached to the first intestinal spiral. Two long and moderately large segmental organs extend

posteriorly to the roots of the dorsal retractor muscles; about the anterior half of the organ is connected with the body-wall by a mesentery.

A large number of specimens from Enoura in the Province of Suruga, referable to this species, are preserved in the Zoological Museum of the Science College, Imperial University of Tokyo. I myself have obtained three specimens from a shallow bottom (5 *hiro* deep) near the Misaki Marine Laboratory. According to SELENKA, HILGENDORF collected the species at Enoura and also at Hakodate. It seems highly probable that this species will be found in more southern localities than Enoura, for the fauna of Enoura, as is admitted by all Japanese zoologists, comprises many subtropical forms.

In dissecting specimens of the present species, it almost always happened that a moderately large globular body was found attached to the dorsal side of the œsophagus nearly always in the same position. I have ascertained by a study of sections that the said body is a sac which contains a number of small parasitic worms; the parasites are imbedded in a dense mass of leucocyte-like cells. Each parasitic worm is externally enveloped by a rather thick cuticula of a bright yellow color; it is provided with a large and a small sucker, both situated on the flattened side of the body. SPENGEL described quite similar worms in the general body-cavity of *Balanoglossus kupferi*; he thought them to be the young of a Distoma species. As to the body-form, the structure and position of the two suckers, *etc.*, I see no noticeable difference of importance between the parasites described by SPENGEL and those found by me in *Phymosoma japonicum*.

PHYMOSOMA ANTILLARUM, GRUBE and OERSTED.

SELENKA, (28), 1883, *p.* 57.

From SELENKA'S description the specific characters of this species may be summed up as follows :

Length of body-proper 3 *cm.*; length of introvert 18 *mm.* Skin yellow, thick, covered with low blackish brown papillæ. On the introvert, the papillæ are of a tall conical form, sparsely distributed. Around the basis of filiform tentacles, of which there are 50-80, there is present a collar-like skin-fold. Two eye-spots on the ganglion.

Longitudinal muscles of the body-wall are divided into bundles, which very frequently anastomose with one another. Intestinal convolution consists of about 20 spirals. Rectal intestine long. Spindle muscle is fixed to the body-wall at both ends. A single fixing muscle joins the first intestinal spiral. Dorsal vessel carries very numerous, finger-shaped contractile villi. Segmental organs are about half as long as the body proper, their entire course being accompanied by a mesentery.

Five specimens of this species were collected on the Islands of Amani-Ōshima (Koniya) and of Okinawashima (Naha, Itoman, Chinensaki). The general external features as well as the anatomical characters agree well with KEFERSTEIN'S original description of this species. The Japanese specimens however are much smaller than those collected in the West Indies (St. Thomas I.). Of the former the largest in my possession does not exceed in

total length 22 *mm.*, of which about 15 *mm.* appertain to the introvert. The number of longitudinal muscles in the anterior half of the body proper, is on an average 14, while in the posterior half each longitudinal muscle divides twice successively before reaching the posterior end of the body. The tentacles, filamentous in form and about 30 in number, are arranged in one row, ventrally and laterally to the mouth. Each tentacle bears in the fresh state, as was mentioned by KEFERSTEIN, two narrow band-like markings of a bluish black color.

The anus and the external apertures of the segmental organs lie at the same level; the latter perforate the body-wall between the second and the third longitudinal muscles. The roots of the two retractor muscles spring from the 2nd–4th longitudinal muscles. Rectal diverticulum is not present. Two distinct eye-spots are found on the ganglion.

Specimens are obtained by breaking coral rocks.

PHYLOSOMA PACIFICUM, KEFERSTEIN.

SELENKA, (28), 1883, *p.* 63.

The main features of the species as embodied in SELENKA'S description are as follows:—

Body proper, 8 *cm.* in length and 14 *mm.* in maximum breadth. Introvert longer than body proper, so that the whole length may reach 29 *cm.* Color grayish, blackish, or reddish brown; often with small black specks; introvert generally bears on the dorsal side irregular pigmented bands. Body-wall thick,

hard, and with very rough surface on account of the presence of tall (0.3 *mm.* high) papillæ which are closely set. Hook-rows 80–100, consisting of tall (0.10 *mm.*) hooks which are provided with a sharp and strongly curved apical tooth and a small blunt accessory tooth. Tentacles 35–40 in number, arranged in a semicircle above the mouth.

Longitudinal muscles, divided into separate but frequently anastomosing bundles, number 30–35 in the posterior half of the body proper. In young individuals, they are sometimes found in the continuous state. Of the four retractor muscle, the ventral pair are rooted in the middle third and the dorsal pair in the anterior third of the body proper. Intestinal spirals, 12–14 in number. Rectal intestine short. Spindle-muscle fixed at both ends. Only one fixing muscle is present. Segmental organs very long, reaching nearly down to the posterior end and accompanied by a mesentery along the whole length.

Numerous specimens of this species were collected by me, in April 1901, on the Islands of Amami-Ōshima (Nase) and of Okinawashima (Chinensaki and Naha). They burrow in fissures of coral rocks along the tide marks.

PHYMOSOMA ONOMICHIANUM, N. SP.

(Figs. 7, 56–58).

The present species is based on a single specimen which I discovered in a collection made by MR. IZUKA, in 1901, in the inlet of Onomichi (Province of Bingo). The specimen is pre-

served in formalin and therefore keeps the natural color almost unchanged.

The animal is of a moderate size (Fig. 7), the body proper measuring about 30 *mm.* in length and 9 *mm.* in maximum breadth. The introvert, which is entirely retracted, is much more slender than the body proper, being only about 2 *mm.* thick. The body-wall is yellowish brown and is covered with large, variously shaped papillæ of a deep brown color. In the middle region of the body proper, the papillæ are but slightly elevated bodies of 0.25 *mm.* basal diameter, each consisting of polygonal chitinous plates of a deep brown color and various sizes (Fig. 56). The small lighter colored area (marked with \times in the fig.) in the centre of the papilla, is perforated by the minute external opening of the subdermal gland. The non-papillated parts of the surface, in this region of the introvert, is covered with sparsely scattered chitinous plates which seem to be of the same character as those of the papillæ. On the introvert-basis as well as in the posterior region of the body proper, the papillæ are conspicuously tall, taking the shape of an obtusely apexed cone (Fig. 57*a*, taken from the region of the introvert-basis). It measures on an average 0.20 *mm.* in height and 0.25 *mm.* in basal diameter, and is constructed of thick chitinous plates of irregularly polygonal shape, closely set together in a pavement-like manner; the plates at the papillar base are the largest and the deepest in color (brown). A small pore (*p*, Fig. 57*b*) opens at the apex of the cone, surrounded by a circular area. No hook or spine is present on the introvert; nor can eye-spots be detected on the ganglion. The tentacles are filamentous and are remarkably numerous, entirely surrounding the mouth.

The longitudinal muscles are divided into separate, but very frequently anastomosing, bundles; in the region of the segmental organs they are 16 in number and in the posterior region of the body about 22. The retractor muscles (Fig. 58) occur in a single ventral pair, the dorsal pair being wanting. The pair present are attached to the body-wall at the beginning of the posterior third of the body proper. The intestinal convolution consists of about 15 double spirals, twisted around the spindle-muscle (*sm*) which is fixed at its posterior end. The intestine is suspended by two fixing muscles (*fm*), both of which lie to the left of the nerve-cord (*n*); one of them arises just behind the root of the left retractor muscle, and is joined to the posterior part of the intestinal convolution, while the other arises at a point of the body-wall about 7 *mm.* in front of the origin of the first and ends at the first spiral. There is no blind diverticulum on the rectum. The anus (*a*) is situated near the anterior end of the body proper, at the same level as the external apertures of the segmental organs. These (*so*) are long, being nearly half as long as the body proper; throughout their whole length they are attached to the body-wall by a thin mesentery. The contractile villi of the dorsal vessel are very numerous and tolerably long, reaching up to 2 *mm.* in length; some of them show a slight ramification.

The most remarkable characters of the species consist (1) in the total absence of hooks and (2) in the retractor muscles being present in a single pair. No form combining these two characters seems to have been hitherto recorded.

Habitat: The sandy shore of the Inlet of Onomichi in the Inland Sea.

PHYMosOMA NAHÆNSE, N. SP.

(Figs. 8, 59–62).

I collected two specimens of this species, in April 1901, at Naha (Naminouye) in Okinawashima, one of the Islands of Riukiu. In external features they closely resemble *Phymosoma scolops* SEL., for which species they were at first mistaken by me.

In the larger of the two specimens, the introvert is entirely protruded, the total body-length measuring 45 *mm.* and the maximum breadth about 8 *mm.* (Fig. 8). The skin is of a brownish yellow color, more deeply tinted at the introvert-basis and at the posterior body-end. Over the entire surface there are distributed tolerably large, but very slightly elevated papillæ. In the middle region of the body proper, these are nearly flat and elliptical in shape, measuring on an average 0.13 *mm.* by 0.10 *mm.* across (Fig. 59). They are thickly covered with numerous round chitinous plates which gradually become larger towards the central area (denoted by \times in the fig.) containing the small aperture of the subdermal gland. The papillæ gradually grow taller towards both ends of the body proper. In the introvert-basis they are on an average 0.2 *mm.* high and towards the posterior end of the body 0.15 *mm.* Hook-rows are numerous and consist of small hooks, about 0.04 *mm.* high, which are provided with a sharp and strongly curved apical tooth (Fig. 60). In the side view of the hook there are seen a transverse bar (*b*) across the base and two rows of warts (*rz*) ("Runzeln"). Both the hooks and the warts are of a reddish yellow color.

Between every two rows of the hooks, there are further found numerous perforated papillæ or "Mündungspapillen" (Fig. 61), a small papillary structure which is so slightly elevated as to measure only 0.02 *mm.* in height. On the apex and around the small aperture of the subdermal gland, there occur in the papilla-wall a few chitinous granules disposed in a small ring.

The longitudinal musculature of the body-wall is divided into 20–30, separate but anastomosing bundles. The retractor muscles are represented by the ventral pair only, the dorsal pair being wanting. The ventral retractors (*vm*, Fig. 62) spring from the middle of the body proper. The dorsal vessel, running along the dorsal side of the œsophagus, is not provided with contractile villi. The intestinal convolution (*ic*) consists of 10 double spirals around the spindle-muscle, which is fixed at both ends to the body-wall. There is only a single fixing muscle (*fm*), which, arising on the left of the nerve-cord, attaches itself to the first spiral. The rectum is tolerably long; it is without a rectal diverticulum. The segmental organs (*so*) are about half as long as the body proper; their external apertures are situated at nearly the same level as the anus. The organs, for the greater part of their length, are connected with the body-wall by a mesentery. The tentacles are about 22 in number; they are relatively short and finger-shaped.

According to SELENKA'S Monograph, there should be known only one species belonging to the genus *Phymosoma*, viz., *Ph. Rüppelli* GRUBE, that is characterised by having hooks and only two retractor muscles. In these respects the present species agrees with *Ph. Rüppelli*, but in the form and structure of the papillæ, in the number of tentacles, etc., it differs from it sufficiently to justify specific distinction.

Habitat: Naha on Okinawashima (one of the Islands of Riukiu), among dead coral masses.

Genus SIPUNCULUS.

SIPUNCULUS NUDUS, LINNÉ.

SELENKA, (28), 1884, *p.* 92.

The main characters of this species are as follows:

Specimens from the Mediterranean Sea, according to GRUBE, may be 2 feet in length, about 8 inches of which appertain to the introvert. The latter is covered with an immense number of large and very high papillæ. The body proper shows on the surface 30–33, mostly 32, longitudinal grooves, which by intersecting the numerous circular grooves form small rectangular areas. The mouth is surrounded by a tentacular membrane which is divided into the dorsal and the ventral lobe, the former being subdivided into large and the latter into small folds—the tentacular flaps.

The longitudinal muscles are divided into 30–33 bundles which very rarely anastomose. Four retractor muscles arise at the same level from the 4th–8th longitudinal muscles. On the rectum are found a small diverticulum and two glandular structures, the “büschelförmige Körper.” The spindle-muscle arises slightly in front of the anus, and is posteriorly free from the

body-wall. Very numerous fixing muscles are attached to the intestine. Segmental organs are so long that their posterior ends reach the roots of the retractor muscles; the anterior one-fifth of their length is fixed to the body-wall by means of mesenteries. Their external opening lies between the 4th and the 5th longitudinal muscle. Eye-spot absent.

Specimens of this species are frequently obtained in the muddy inlets near the Misaki Marine Laboratory. They are very common along the muddy shores of Tateyama (Province of Bōshyū) and of many localities along the Inland Sea. I have had the opportunity of comparing the Japanese specimens with two well preserved specimens of the same species from Naples. In external as well as internal aspects the Japanese specimens agree well with SELENKA's description, except in the number of the longitudinal muscles of the body-wall. In the Mediterranean specimens the said muscles are, as was pointed out by SELENKA, 32 in number, while in the Japanese forms they number constantly 30.

SIPUNCULUS CUMANENSIS, KEFERSTEIN.

(Fig. 63).

SELENKA, (28), 1884, p. 104.

The main characters of this species may briefly be stated as follows :

Body large, elongate; introvert about one-third of the total length. Skin thick, quite opaque, yellowish or reddish brown in

color. Skin-bodies small and flat, containing a few hook-like structures (?) with the points directed outwards. At introvert-basis and near the posterior end of body, the skin-bodies though but slightly elevated above the surface are so large (0.38–0.4 *mm.* in diameter) as to be easily recognized with the naked eye.

Longitudinal muscles average 20 in number; they are broad and anastomose but rarely. Circular muscles are likewise divided into distinct but narrower bundles. Four retractor muscles arise a short distance behind the anus, the ventral pair between the 7th and the 8th longitudinal muscle. Rectal diverticulum present. Spindle-muscle fixed to the body-wall at both its ends, anteriorly giving off two lateral branches. The single fixing muscle has two roots. Dorsal vessel with numerous but short contractile villi. Segmental organs short, connected with the body-wall for the anterior one-fourth of their length by a mesentery; their external apertures lie between the 3rd and 4th longitudinal muscle. A large number of crescent-shaped dissepiments are present on the inside of body-wall in the region between the anus and the posterior body-end.

This cosmopolitan species is very widely distributed in Japan. Numerous specimens have been obtained from various localities; as for instance, Kamo (Province of Rikuzen); coasts of the Tokyo and Sagami Bays and of the Inland sea; Kagoshima (Kiusiu); Koniya in Amami-Ōshima; Naha and Itoman (Riukiu). The specimens from various localities in Japan proper, including those from Kagoshima, are 20–30 *cm.* in total length and 8–12 *mm.* in breadth, the introvert and the body proper being nearly uniformly broad. The color is yellowish brown in the male and reddish brown in the female. On the other hand, the specimens

from Naha and Koniya are much smaller, while the body-wall, which is rough on the surface, is thicker and more deeply brown in color, without however showing any recognizable difference in internal anatomy. But as compared with foreign specimens, all the Japanese forms seem to show some points of structural deviation as will be gleaned from the following account.

The longitudinal muscles are divided into 18–21 (mostly 20) separate bundles which very rarely anastomose with one another; the circular muscles are also separated into more or less regular bundles. Of the four retractor muscles, the dorsal pair arise from the 7th–9th longitudinal muscles; the ventral pair from the 1st–4th (mostly the 1st–2nd). The roots of all these muscles are situated nearly at the same level. The two lateral branches of the spindle-muscle are attached to the 9th or the 10th longitudinal muscle, close to the root of the dorsal retractor muscle; the main bundle does not end posteriorly in a single root but divides into 3–5 branches which give off still finer ones in order to join the body-wall.

The ‘Ovale Gebilde’ which was first described by KEFERSTEIN from German specimens, is present also in all the Japanese specimens I have dissected. As was already noticed by other authors, these structures are seen as small oblong bodies closely adhering to the inner surface of the body-wall. Their longer diameter measures 0.5 *mm.* on an average. Sometimes they are found lying on the longitudinal muscles and sometimes between them. They are most abundant in the anal region. When seen in the fresh state, they appear as colorless transparent spots. A study of the bodies on sections has revealed the fact that they are of quite a different structure from those which were described by KEFERSTEIN. According to that author, the bodies should present an appearance of skin papillæ and should inclose a peculiar kind of hook, 0.08–

0.10 *mm.* high and made up of a substance which is not acted upon by acetic acid or soda. Now in the Japanese specimens, neither hook nor any other solid body can be detected in the interior of the organ; the organ is evidently a saccular gland opening by a short narrow duct to the exterior. Fig. 63 represents a portion of a cross-section through the body-wall, passing through one of the organs under consideration. As may be seen from that figure, the organ incloses a cavity and thus represents a thick-walled sac, the wall being composed of two distinct layers. The external layer (*el*) again consists of two layers, the peritoneal covering and a connective-tissue layer, both of which are continuous with the corresponding layers on the inside of the integument. The far thicker internal layer (*gl*) of the organ is formed of an epithelial row of very tall and large cells with granular contents. The granulation of the latter is in some cells coarse, in others much finer. Staining reactions show that the granules are closely allied to mucin. The nucleus is mostly found situated close to the inner end of the cells. The outleading canal of the gland runs through the thick muscular body-wall to open by an external pore. (The section of Fig. 63 did not pass right through the length of the duct lumen, but the course of this duct is partially indicated by its fibrous investment.)*

* Lately I have had the opportunity of reading HERMANN AUGENER's paper "Beiträge zur Kenntniss der Gephyreen" (Berlin, 1903), in which the author gives a detailed account of the histological nature of the "*Ovale Gebilde*" or his "*Keferstein'sche Bläschen*." The author doubts the correctness of Keferstein's representation of the structures as papillary bodies containing hooks. He considers the wall (exclusive of the peritoneal and the connective-tissue covering) of the body as consisting of two cellular layers: an inner layer, directly lining the lumen of the body and showing a distinctly epithelial character, being composed of radially arranged spindle-like cells with similarly shaped nucleus; and an outer layer of a more connective-tissue-like appearance containing large lacunar spaces and spindle-shaped nuclei. As the author himself makes the statements with much reserve, I am led to doubt their validity; probably the appearances described by him were due to some inappropriate methods of preparation. According to my experience, fixing reagents

SIPUNCULUS AMAMIENSIS, N. SP.

(Figs. 64-65).

The species is of a tolerably large size, the body proper measuring 100-120 *mm.* in length and 10-15 *mm.* in thickness and the length of the introvert being about one-fourth that of the body proper. The color is yellowish brown in the body proper, and a deeper brown in the introvert. The skin-surface is rough, especially at the introvert-basis and at the posterior end of the body, both these parts being covered with the largest skin-bodies. In the middle of the main region of the body, the skin-bodies are nearly flat and of a circular form, measuring about 0.075 *mm.* in diameter (Fig. 64). They are each covered with a thick and finely granular chitinous layer of a yellow color. The central part of this covering is occupied by a relatively large, circular and colorless area which is composed of larger, closely aggregated chitinous granules. Between the papillæ the chitinous layer of the skin forms irregular and interrupted wrinkle-like folds, which divide the surface into irregular mesh-like areas. Near the anterior end of the introvert, immediately behind the tentacles, the chitin folds wholly disappear, and instead of them there appear narrow grooves intersecting one another at right angles so as to bring about a tessellated pattern.

make the structure in question much too hard and brittle for the preparation of good sections. However that may be, I have no doubt that the two layers described by AUGENER collectively correspond to the single epithelial layer I have seen and the glandular nature of which seems to be plain from the reaction shown by the granular contents of the cells towards stains.

As to the physiological significance of the bodies, AUGENER too has suggested the view that they may be regarded as "drüsenartige Gebilde" (p. 63), though this was not proved by him from the histological standpoint.

No hook or spine is present on the introvert. The tentacles are filamentous and about 80 in number; they are arranged in 16 rows, the oral ends of each set of two rows being joined by a U-shaped ridge.

The longitudinal muscles are divided into 15 broad bundles which rarely anastomose with one another in the region of the introvert. Of the four slender retractor muscles, the ventral pair are the larger and spring from the 2nd—3rd longitudinal muscles in the middle region of the body proper, while the dorsal pair arise far more anteriorly from the fourth longitudinal muscles on both sides (Fig. 65, *vm* and *dm*). The dorsal vessel (*dv*) is seen running along the whole posterior course of the œsophagus and gives off very numerous short contractile villi. The spindle-muscle (*sm*), fixed at both ends to the body-wall, gives off two lateral branches (*sm'*) at the very beginning of the intestinal convolution. These branches end on the 6th longitudinal muscles, nearly at the same level as the roots of the dorsal retractor muscles (*dm*). There are, besides, two stout fixing muscles (*fm*): one arises from the 4th longitudinal muscle, close to the roots of the right retractor, and is attached to the beginning of the rectum; the other springs with two roots from the first longitudinal muscle and is attached to the œsophagus near the intestinal convolution. The segmental organs (*so*) are small sacs of a deep reddish brown color; the external apertures lie at the same level as the anus. The organs are entirely free of a mesentery. On the dorsal lip of the funnel or the internal opening, we constantly see two or more small processes, some of which may subdivide into 2 or 3 branches. They seem to be made up simply of the connective-tissue and of the external peritoneal covering. I am at present unable to make any sug-

gestion as to the physiological nature of the structure. There is no rectal diverticulum. Nor is there an eye-spot present on the ganglion.

The present species seems to be most nearly allied to *Sipunculus rotumanus* SHIPLEY and *S. funafuti* SHIPLEY (32). But those two species may both be distinguished from the present by the peculiar form and color of their papillæ as well as by the absence of fixing muscles. Besides, *S. funafuti* is so peculiar in color and body-form, that it bears no resemblance to the present species in external aspects.

Habitat : Numerous specimens were collected by me, in April 1901, at Koniya (Amami-Ōshima), and a single one at Naha (Okinawashima). All were found near the shore in coral sand.

Genus ASPIDOSIPHON.

ASPIDOSIPHON TRUNCATUS, KEFERSTEIN.

(Figs. 66-67).

SELENKA, (28), 1883, p. 118.

The main characters of this species are indicated in the following extract from SELENKA's description :

Color brown all over, but deeper on the anal and caudal shields, both of which are radially grooved. Papillæ small,

slightly larger in the region of the caudal shield. Very numerous rows of very small hooks with incompletely bifurcated apex and bearing warts ("Runzeln") at base. Small spines are scattered to a wide extent behind the hook-rows. Longitudinal muscles partially divided into irregular, frequently anastomosing bundles, which are however more or less regularly developed on the inside of the anal shield. Retractor muscles spring with two roots from the inside of the caudal shield. Intestinal double spirals are traversed by a spindle-muscle fixed at both ends to the body-wall. Rectal diverticulum distinct. Segmental organs long and large, attached to the body-wall by mesenteries throughout nearly their entire length.

Several specimens of this species were collected by MR. MIYAJIMA (1900) and by myself (1901) in Okinawashima (Naha) and Amami-Ōshima (Koniya). The largest specimens in the fully extended state measure 5 *cm.* in total length. In the preserved state, the larger ones have a yellowish brown color and the smaller a light reddish yellow color. The anal and caudal shields are of a deep brown.

The external features and the anatomical characters agree well with the description given by SELENKA. What slight differences seem to exist, are as follows:

On the concave side of the hook, just at the base of the small accessory tooth, a few very fine, thread-like processes of chitin are produced inwards from the spot mentioned (Fig. 66). Between hook-rows there are scattered small tubular papillæ (Fig. 67). Each papilla rests on a low basal prominence which is covered with relatively large chitinous granules (*x*).

The worms live in dead coral masses or in eroded coral rocks.

ASPIDOSIPHON STEENSTRUPII, DIESING.

SELENKA (28), 1883, *p.* 116.

The main characters of this species, taken from SELENKA's description, are as follows :

Introvert and body proper nearly equally long. Color light yellowish brown, nearly black at both ends of body proper. Skin-bodies formed of closely aggregated polygonal plates, four or more of which lie in the center ; each of the latter plates with a small plate. The two shields are of a nearly flat hemispherical form, lightly grooved radially and circularly ; formed of small oval or polygonal bodies, those lying in the periphery being largest. Introvert with small double-toothed hooks arranged in complete rings and with a great number of relatively tall perforated papillæ (" Ausmündungspapillen "). Longitudinal muscle, in the posterior part, separating into about 25, frequently anastomosing bundles ; anteriorly these gradually diminish in number till they all coalesce into a continuous layer. Retractor muscles spring from the beginning of the posterior fourth of the body proper, the line of their origin extending from the 3rd to the 7th (sometimes to the 8th) longitudinal muscle. Spindle muscle fixed to body-wall at both ends. Rectal diverticulum present. Fixing muscle said to be absent, except in specimens from the Philippines, from which SELENKA has described a single fixing muscle attached to the 1st or the 2nd intestinal spiral. No contractile villi. Segmental organs long, posteriorly reaching to the roots of the retractor muscles ; their anterior

half accompanied by a mesentery. Two eye-spots present on the ganglion.

This species is one of the commonest Sipunculoids met with in the Riukiu and the Amami-Ōshima Islands.

As in the Philippine specimens described by SELENKA, a fixing muscle is distinctly present. But it may be pointed out that unlike them the muscle terminates on the intestine not with one end, but with two branches; one of these is attached to the hindmost part of the œsophagus, while the other is joined to the spindle muscle just at the beginning of the intestinal convolution. The hooks on the introvert are provided with two distinct rows of small warts lying at the hook base. This fact has not been mentioned in the case of foreign specimens of the species.

ASPIDOSIPHON MISAKIENSIS, N. SP.

(Figs. 9, 68-72).

This species is a small form (Fig. 9). The body proper rarely exceeds 20 *mm.* in length and 5 *mm.* in width; the introvert is unusually long, being at least three times as long as the body proper. The color in the fresh state is a light brownish pink, the introvert-basis as well as the anal and caudal shields being shaded a deeper brown. The anal shield is oval in shape and is composed of minute calcareous granules of a deep brown color; only the periphery of this shield exhibits short radial grooves (Fig. 68). In the anal region, the skin is covered with large and closely set papillæ of a deep brown color which are composed

of small granules hardened more or less by the deposition of some calcareous matter. In the middle region of the body proper, the papillæ are nearly flat, measuring 0.15–0.10 *mm.* in diameter. Over their surface there are aggregated numerous irregularly polygonal chitinous plates of various sizes and of a light brownish yellow or true yellow color. One roundish plate in the center is perforated by the opening of the subdermal gland. The caudal shield is of a conical shape and a deep brown color. Like the anal shield, it is constructed of small calcareous granules, and the margin alone is slightly folded radially. Just behind the tentacular region of the introvert, there follow about 35 complete hook-rows. The hook, 0.032 *mm.* high and yellowish brown in color, is supplied with two sharp teeth (Fig. 69). Behind the hook-rows, there are distributed numerous gently curved spines 0.045 *mm.* in height (Fig. 70). The papillæ on the introvert are represented by a small colorless hyaline tube standing on a tubercle-like base (Fig. 71).

The longitudinal muscle in young specimens is quite continuous, while in the adult it is partially divided into indefinite bundles anastomosing very frequently. There are only two retractor muscles, the ventral pair, which arise very close to the caudal shield (*vm*, Fig. 72). For the greater part of their course, they are fused into one band. The dorsal vessel (*dv*) is very short (about 2–3 *mm.* in length) and has no contractile villi. The intestinal convolution (*ic*) consists of irregular and loosely twisted spirals indicating no definite number of turns. The spindle muscle is, fixed to the body-wall at both ends. A small blind sac (*rg*) is attached to the middle part of the long rectum. Only one slender fixing muscle (*fm*) is present, attached to the first spiral of the intestinal convolution at one end and at the other

to a point on the left of the nerve-cord and close to it, far more anteriorly than the root of the retractor muscle on the same side. The segmental organs (*so*) are remarkably long, being equal to two-thirds of the length of the body proper. The organs are fixed throughout their whole length to the body-wall by a mesentery. The tentacles are short and thick, numbering 8-10. Two eye-spots are present on the ganglion.

Among the hitherto known *Aspidosiphon* species, *A. elegans* CHAM. & EISENH. seems to be most closely allied to the present species. However the two species in question may be distinguished from each other by different features of the anal and caudal shields and by the difference in the size and form of the hooks and spines.

Habitat: I have collected the species only at Misaki, along rocky shores in the vicinity of the Marine Laboratory.

ASPIDOSIPHON UNISCUTATUS, N. SP.

(Figs. 10, 73 — 77).

The unique specimen (shown in Fig. 10) on which this species is based, was found in MR. MIYAJIMA'S collection made at Kataura in the province of Satsuma (1900). In its present state, preserved in alcohol, the body proper measures 13.5 *mm.* in length and 3.5 *mm.* in maximum width. The skin, which is relatively thick, is yellowish brown becoming a deeper brown towards the anal shield. The latter, deep reddish brown in color, is of a tall helmet-like shape, obliquely truncated at the

basal border. The wall of this shield is unusually thick and hard on account of the deposition of a calcareous substance. Its surface is sculptured into numerous longitudinal ridges and grooves that converge towards the rounded apex. When examined under a certain magnification, the ridges are seen to be covered with small chitinous bodies of a deep brown color (Fig. 73), and at the hindmost end of each ridge there is situated a large papilla consisting likewise of chitinous bodies similar to those of the remaining part of the ridge. The center of this papilla shows a circular space formed of small and light-colored plates and surrounded by 2-3 rings of very dark-colored plates. The apical parts of the shield are stripped of the epidermis, thus exposing the underlying white calcareous layer. The skin-surface adjacent to the shield is closely beset with papillæ which appear as deep brown spots. These latter are structurally the same as those of the papillæ lying at the basal border of the anal shield, though they are somewhat smaller. In the middle and posterior regions of the body, the papillæ are quite flat, and are formed of many polygonal chitinous plates separated from one another by narrow grooves (Fig. 74). These plates are smaller towards the center of the papilla, where the pore of the subdermal gland is situated. The caudal shield is not definitely marked off, but is simply indicated by a darker brown color. The aperture of the introvert lies just below the ventral border of the anal shield, so that the introvert as a whole stands out nearly at right angle from the body proper. The introvert is about as long as the body proper, and is of a light yellowish brown color. The anterior portion carries numerous complete ring-rows of hooks which are 0.04 *mm.* long and of a reddish yellow color (Fig. 75). Between these rows are scattered tubular papillæ

(Fig. 76) which are hyaline and colorless and measure about 0.015 *mm.* in height.

The longitudinal muscle is, in the middle of the main part of the body, divided into frequently anastomosing bundles, but is quite continuous in the region of the introvert-basis and in the posterior fourth of the body proper. The sexual organs (*sx*, Fig. 77) are developed as two slender wavy bands at the roots of the retractor muscles (*vm*). The intestinal convolution (*ic*) consists of about 12 spirals, and is traversed by the spindle muscle (*sm*) which is fixed to the body-wall at both ends. There is no fixing muscle at all. The blind diverticulum (*rg*) is attached to the middle part of the rectum. The segmental organs (*so*) are in length equal to about two-thirds of the body proper, and are of a pale reddish brown color. The organs are for the whole length accompanied by a mesentery. Their external apertures are situated at the same level as the anus (*a*). The anterior terminal portion of the rectum is provided with well-developed wing-muscles (*wm*). Two brown eye-spots on the ganglion (*g*). Tentacles short, 10 in number.

Habitat: Kataura in the province of Satsuma. The worm was found in a small hole bored through a small piece of dead coral.

ASPIDOSIPHON ANGULATUS, N. SP.

(Figs. 11, 78-80)

Only one specimen of this species has been collected by me (1901) in the Inlet of Katsuyoki in the Amami-Oshima Island. It lived in a dead coral that was exposed at low tide. The

animal (Fig. 11) is small, measuring 15 *mm.* in length of the body proper. The introvert is nearly as long as the body proper, but only half as thick. The skin is very thin, smooth, partly transparent and of a light reddish brown except at the anterior end of the body proper, where it is a deeper brown and of a rough granular appearance. The anal shield may be said to consist of an obliquely conical main part and of a short, cylindrical, basal part. The former has the surface marked with distinct radial grooves. The basal part also shows grooves which alternate in position with those in the conical part (see Fig. 11). The entire shield is formed of small, densely aggregated chitinous plates. The caudal shield is in the shape of two cones juxtaposed at base; it is radially grooved, the grooves on the two cones alternating (see the above figure). The greater part of the body proper shows no papillary structure; only by using a high power of the microscope can the numberless small openings of the subdermal glands be discovered. Just in front of the caudal shield there are seen some slightly prominent papillary bodies measuring 0.06–0.10 *mm.* in diameter. They are formed of small polygonal chitinous plates of a light yellowish brown color (Fig. 78). The plates are somewhat smaller in the central part of the papilla than in the periphery; the most centrally situated plate bears the pore of the subdermal gland. Around the base of the anal shield, the papillae are larger (commonly 0.10 *mm.* in diameter) and of a deeper brown than in the posterior region. Very numerous hook-rows are present on the introvert surface. The hooks (Fig. 79), 0.02 *mm.* high on an average, have a bluntly pointed apex; they are of a light yellow color. Between these hook-rows there are distributed small tubular papillae. No spines can be detected behind the hook-rows.

The longitudinal muscles are incompletely divided into frequently anastomosing bundles. Two retractor muscles, the ventral pair (*vm*), arise slightly behind the middle of the body (Fig. 80 Pl. IV). The sexual organs (*so*) are situated at a short distance behind the roots of these muscles. The intestine is convoluted into about 15 spirals. The spindle muscle (*sm*) is fixed to the body-wall at both ends. No fixing muscle and no rectal diverticulum are present. Peculiar to this species is the fact that the oesophagus (*os*) is attached to the retractor muscle at a point so far from the fusing point of the right and left retractors, that it appears to be entirely free from the muscle. The segmental organs (*so*) are about one-third as long as the body proper; their posterior halves are free of the mesentery joining them to the body-wall. On the dorsal lip of the internal opening or funnel, there is present a very small sac-like body. Eye-spots cannot be discovered. The filamentous tentacles are probably 10 in number.

ASPIDOSIPHON SPINALIS, N. SP.

(Figs. 12, 81-85)

The animals (Fig. 12) belonging to this new species are of small size, the body proper being generally about 10-15 *mm.* long (28 *mm.* in one specimen) and about 3 *mm.* in breadth. The skin appears smooth, and has a light yellowish brown color in the main part of the body proper, but is rough and of a deeper brown on the anal shield and the dorsal side of the introvert.

As in *Aspidosiphon angulatus*, no distinct papilla or skin-body is present, except the small pores of the subdermal glands. The anal shield is an elliptical and nearly flat body, covered with large brown papillæ. These are composed of minute chitinous granules. The caudal shield is not so thick, nor so distinctly contoured as the anal shield. Its peripheral portion alone is marked with small chitinous granules of a brown color. Confined to the vicinity of the two shields, are the papillary bodies; they are very slightly elevated, elliptical in form, brownish in color, and measure on an average 0.15 mm. by 0.09 mm. in the two diameters. The papillæ (Fig. 81, Pl. III) show the same structure as those of *Aspidosiphon angulatus*, except in the one unimportant respect that the chitinous plates are in general larger than in that species. The introvert is nearly as long as the body proper; its posterior half is deep brown on account of the presence of spines of that color. The spines (Fig. 82) are straight, sharply pointed, broad at base and are formed of a thin chitinous lamina folded in a funnel-like manner; they are 0.04 mm. high in the anterior region, but become gradually taller towards the introvert-basis where they measure 0.07 mm. in height. These spines are distributed over almost the whole surface of the introvert, but are most closely aggregated on the dorsal side of the posterior half of the part, thus giving to this region a deeper brown color than elsewhere. In the anteriormost parts of the introvert, there are found numerous complete rows of brown colored hooks. The hook (Fig. 83) is 0.05 mm. high and is provided with two sharp teeth at apex. In the interspaces between hook-rows there occur small colorless and transparent tubular papillæ (Fig. 84) about 0.03 mm. high.

The longitudinal muscles are entirely continuous. The two

(ventral) retractor muscles (*vm*, Fig. 85) arise just in front of the caudal shield. The intestinal convolution (*ic*) consists of 10–15 spirals, traversed by the spindle muscle (*sm*), which is fixed to the body-wall at both ends. No fixing muscle is present. The rectum is long and lacks a diverticulum. The anus is situated just behind the anal shield. The two segmental organs (*so*) of a reddish brown are about as long as the body proper and are fixed to the body-wall by a mesentery along their entire length. Their external apertures lie a short distance behind the anus. The two eye-spots appear as brown specks on the ganglion.

Habitat: Numerous specimens of this species were found (April 1901) in dead corals, at Koniya in Amami-Ōshima Island.

Genus **CLÆOSIPHON.**

CLÆOSIPHON JAPONICUM, N. SP.

(Figs. 13, 86–89).

This species is one of the commonest Sipunculoids met with in the Riukiu and Amami-Ōshima Islands. The general external and internal characters seem at first glance to agree well with those of *Cleosiphon aspergillum* QUATREFAGES, *C. mollis* SELENKA & BÜLOW or *C. javanicum* SLUITER, but careful examinations bring to light some important points characteristic of each of the

species mentioned, especially in regard to their external features. As to its internal characters, the present species may be said to be almost identical with *C. aspergillum* and *C. javanicum*, except in the facts that the longitudinal muscle is not separated into bundles and that the sexual organs are not developed in the same position as in *C. javanicum*.

The species has long cylindrical body which may reach about 7 cm. in length and 7 mm. in width. The posterior end of the body is rounded in the fresh state. As was noticed by SHIPLEY (31) in *C. javanicum*, the external appearance of the species is subject to considerable individual variation, but as a general rule two types of characters are distinguishable. In the one the skin is thick and of a deep brown and the calcareous shield, composed of calcareous papillæ, is as wide as the body proper; while in the other the skin is thin, nearly transparent and of a reddish brown and the shield, consisting of very small papillæ, is narrower than the body proper. According to my own observations, however, these differences are in a great measure those of the sex. The first type referred to being seen mostly in the male and the second in the female. Fig. 13 is taken from a large male in the living state.

The anal shield, which shows a structure peculiar to the genus, presents varying shapes according to the state of contraction, a fact previously noted by SLUITER (35) in *C. javanicum*; it assumes all sorts of forms varying from that of a depressed disc to that of a cone. The shield is made up of numerous milky-white calcareous papillæ which are spirally arranged and become gradually smaller towards the posterior border (Fig. 86). The papillæ are mostly of a hexahedric form, but their external facets present rather irregular shapes, being quadrate, rhomboidal,

pentagonal and rarely polygonal. A condition similar to the above has also been noticed by SELENKA (28) in *C. mollis*. The edges of the external facets are not sharp, but bevelled and are pigmented a deep brown in the fresh state. The center of each external facet, which is perfectly flat, is occupied by a small, deep brown, circular pore of the underlying papillary gland. Skin-papillæ are scattered over the entire surface of the body proper, and are so large that they may be detected with the naked eye; they are especially densely aggregated near the base of the shield. Under the microscope each papilla appears as a slightly prominent body of a brown or yellowish brown color. Its peripheral portion is formed of two irregular but concentric rings of small chitinous plates, while the central portion is roofed by a thin chitinous layer which is often incomplete as shown in Fig. 87. The subdermal gland opens at the center of the papillæ. The papillæ measure, in the middle region of the body proper, about 0.08 mm. in diameter. They become gradually shorter but stouter towards the posterior end, while on the other hand they become taller and more slender towards the base of the calcareous shield. On the introvert-basis, they are remarkably tall, measuring 0.10 mm. in average height; they appear as cylindrical protuberances of a coarsely granular appearance (Fig. 88). Chitinous granules are distributed also over the non-papillated part of the skin. There are present about 20–25 complete ring-rows of hooks. These are 0.10 mm. high and of a brown color, and are provided with two sharp curved teeth (Fig. 89). As was figured by SLUITER from *C. javanicum*, there are a few small processes situated just below and inside the accessory tooth. At the hook-basis there lie two small transverse bars and two rows of warts (see the above figure). In the interspaces between hook-rows there

are distributed numerous tubular or perforated papillæ (Fig. 89); the upper or free edge of these is guarded by a row of very small chitinous teeth.

In the individuals which I regard as the female, not only the shield itself, but also the calcareous papillæ on it, are much smaller than in those which I regard as the male. Besides, in the former case all the papillæ are nearly of the same size. Some individuals are characterised by a peculiarly modified shield; the calcareous papillæ found at the apex of such shields are elongated into long processes of a deep brown color. Quite a similar feature was described by SLUITER in connexion with the shield of *C. javanicum*.

Cleosiphon japonicum must be regarded as a distinct species differing in several important points from the hitherto known species, viz., *C. aspergillum*, *C. mollis* and *C. javanicum*. It differs from *C. aspergillum* in the irregular forms of its calcareous papillæ, in the structure of its skin-papillæ (of the introvert-basis as well as of the body proper) and in having the warts and the perforated papillæ. Neither *C. mollis* nor *C. javanicum* have the two structures last mentioned. *C. mollis* may be distinguished from *C. aspergillum* by the presence of very small hooks and the absence of eye-spots,—points of difference which exist also between *C. mollis* and the present species. Lastly, the differences between *C. javanicum* and the present species are most remarkable; in the former species one edge of the external facet of the calcareous papilla being said to be considerably raised, and the aperture of the papillary gland on the facet, elliptical in shape. Besides these two points, the characteristic broad form of the hooks and the formation of the longitudinal muscles into bundles are quite peculiar to *C. javanicum*.

The internal anatomy of the present species may be briefly outlined as follows :

The longitudinal muscle is quite continuous. The retractor muscle arises with two roots at the beginning of the posterior fifth of the body proper. Double intestinal spirals number about 12. Spindle muscle fixed at both ends. Only one fixing muscle attached to the beginning of rectum. Segmental organs connected with the body-wall along their whole length by mesentery. No rectal gland. Two distinct eye-spots are present on the ganglion.

Genus DENDROSTOMA.

DENDROSTOMA BLANDUM, SELENKA & DE MAN.

(Figs. 14, 90 & 91).

SELENKA, (28), 1883, *p.* 85.

The main characters of this species are summed up in the following extract from SELENKA's description :

Body of a stunted form ; introvert one-third as long as body proper. Color brownish or reddish gray. On the middle region of the introvert are scattered numerous large and sharply pointed black hooks 0.4 *mm.* in height. Papillæ in the middle region of the body proper, low, oval, 0.07–0.09 *mm.* in diameter ; in the

central part of each papilla there is a clear area surrounded by small horny granules. Papillæ on introvert-basis and on the posterior end of body, slightly larger; most prominent just behind the hood-region of introvert. Small papillæ also present in the hooked region of introvert. Tentacles arise from several (5-6) main stems. Two retractor muscles arise from the middle third of the body proper. Two segmental organs about half as long as the body proper; mesentery entirely lacking. Posterior end of spindle muscle not attached to the body-wall. Three fixing muscles; one of them attached to the rectum and the others to the œsophagus. Contractile villi remarkably long, but few in number.

Two alcoholic specimens of this species were found in a zoological collection made in the Hokkaidō in 1900 by MR. IZUKA; one of them is from Wakkanai (near Cape Sōya) and the other from the harbor of Aomori. The latter specimen (Fig. 14) is the better preserved, measuring 2.5 *mm.* in length of the body proper. Both specimens are of a brown color in the preserved state. The introvert-basis shows on the skin-surface fine circular, and somewhat coarser, longitudinal furrows.

As to the skin-structures and the general anatomy, the specimens agree within certain limits with SELENKA's description of *Dendrostoma blandum* which was many years ago obtained by HILGENDORF at Enoshima. But careful studies of my specimens disclose some important points which either were omitted by SELENKA, or are irreconcilable with, his description. However, I do not feel fully justified in establishing a new species on the strength of these apparent differences, since the specimens at my disposal seem too few to be conclusive.

The papillæ of the body proper and of the introvert, are nearly of the same form, size, and structure as in HILGENDORF'S specimens. The scattered hooks also show the same form and color as in those specimens, but are very much smaller (0.20 *mm.* high), being only half as high as HILGENDORF'S (0.40 *mm.*). The tentacles are reddish brown. In my specimens, they are given off from the free margins of the eight arms produced by the dichotomous branching of each of the four main stems (Fig. 90). Some few short tentacles are also present along the inner margin of each main stem. The above mode of branching of the tentacular stems is not described by SELENKA, who on the other hand states that the main stems are 5 or 6 in number.

In one specimen—that from Aomori—there are four fixing muscles to the intestine, two on each side of the nerve-cord. On either side, one muscle is attached to the œsophagus near the posterior extremity of the dorsal vessel and the other to the first intestinal spiral; both arise from the body-wall close to each other, far in front of the roots of the retractor muscles and widely separated from the ventral nerve-cord. In the other specimen—that from Wakkanai—one of the fixing muscles of the left side is wanting, the single muscle present on that side dividing into two short branches (Fig. 91). Both of the latter are attached to the first spiral of the intestinal convolution (one to the œsophageal, and the other to the rectal, section of the intestine. Close to the entrance to the convolution, there is present on the rectum a distinct blind diverticulum (*rg*, Fig. 91), an organ which has not been mentioned by SELENKA from HILGENDORF'S specimens. The fixing muscles are stated by SELENKA to be only two in number.

DENDROSTOMA SIGNIFER, SELENKA & DE MAN.

(Fig. 15).

SELENKA, (28), 1884, *p.* 86.

The main features of the species are embodied in the following extract from SELENKA :

Body of a stunted form, tapering posteriorly to a sharp point; introvert about one-fourth as long as the body proper. Color brownish or yellowish red, with a dark blue band at the middle of the introvert. Skin-bodies very small (0.06 *mm.* in diameter), quite flat; represented by oval areas, from the center of which a narrow canal leads down to the granular layer below. Hooks generally wanting. Tentacles very numerous, springing from 5 or 6 main stems. Eye-spots present.

Longitudinal muscle continuous. Two strong (ventral) retractor muscles arise from the beginning of the posterior third of the body proper. Intestinal spirals 15–20 in number, traversed by a spindle muscle not fixed to the body-wall at its posterior end. Three fixing muscles: one attached to rectum and two to œsophagus. Contractile villi very numerous, long, and branching.

Four specimens (Fig. 15) of the above species were collected in the Riukiu Islands. They were found in holes bored through dead corals. All measure about 30 *mm.* in total length. They tally well with SELENKA's description of the Phillippine specimens,

except in the facts that the main tentacular stems are constantly four in number (instead of 5 or 6) and that the hooks are entirely wanting in all the specimens. There occurs on the rectum a distinct blind diverticulum such as has not been noticed in any species of *Dendrostoma* yet described.

DENDROSTOMA MINOR, N. SP.

(Figs. 16, 92-95).

This species is a small form, not exceeding 15 *mm.* in length and 3 *mm.* in breadth. The introvert is one-third as long as the body proper. The worms in the fresh state are of a yellowish brown color, only the anterior portion of the introvert being of a light violet tint. The whole surface of the skin is covered with small papillæ which are nearly flat in the middle main region of the body proper. But in the anterior and posterior regions, the papillæ are somewhat raised and appear as oval tubercles of 0.02-0.03 *mm.* height and 0.10 *mm.* long diameter (Fig. 92). They are formed of numerous polygonal chitinous plates which are larger towards the center of the papillæ; one plate in the center contains the opening of the subdermal gland. In the hooked region of the introvert, the papillæ are much smaller, but are of nearly the same height, appearing like a hemispherical tubercle resting upon a broader basal elevation (Fig. 93). Hooks, about 50 in number, are found scattered in the anterior parts of the introvert (Fig. 94). They are 0.04 *mm.* high, blackish brown in color, slightly curved and bluntly pointed at apex. Specimens from Funakawa in the province of Ugo (on

the Japan Sea) differ from those from other localities in having fewer but larger hooks, 20–30 in number and about 0.06 *mm.* in height. The tentacles are given off from four stems: these latter split each into two branches; each branch again divides into 4–6 long tentacles which are of a violet color except at the bright yellow tip.

The longitudinal muscle is continuous. There exists only one pair of retractor muscles (the ventral), originating in the middle of the body proper or at a somewhat more posterior point. The dorsal vessel, running along the dorsal side of the œsophagus, bears numerous, tolerably long, contractile villi (*cv*, Fig. 95). The intestinal convolution, consisting of 7–12 spirals, is loose and irregular, especially in young specimens. The spindle muscle is not attached to the body proper at the posterior end of the body. The rectal portion of the intestine is tolerably long and bears at its beginning a small blind diverticulum (*rg*). Of fixing muscles there are present sometimes two, sometimes only one and in still other specimens, none at all. When present in a pair, both are attached to the first intestinal spiral and end on both sides of the nerve-cord; when present singly, the muscle is on the left side. The segmental organs (*so*) are about one-third as long as the body proper, and are entirely devoid of a mesentery. Their external apertures lie at the same level as the anus. Eye-spots are present on the ganglion.

The present species in the manner of the branching of its tentacles and in their color resembles *Dendrostoma alutaceum* GRUBE, but is quite different from that species in the form, size, and structure of the papillæ, in the size of the hooks, in the number of contractile villi and in the total size of the worm-body.

Habitat: Specimens of the species have been collected at

Funakawa in the Province of Ugo, Misaki, Habu on Ōshima (Izu Province), and Tanegashima, a small island near Kagoshima. The species lives under algæ covering rocks along the tide-marks

ECHIUROIDEA.

Genus ECHIURUS.

ECHIURUS UNICINCTUS, VON DRASCHE.

SELENKA (29), 1885, *p.* 385.

RIETSCH (26), 1886, *p.* 188.

SHIPLEY (31), 1899, *p.* 344.

EMBLETON (8), 1900, *p.* 77.

SHIPLEY's diagnosis runs as follows:

"Length of body averages 8.5 *cm.*; length of proboscis, 5–6 *mm.* when contracted. Color, bright yellowish brown. Papillæ uniform in size, only arranged in transverse rows in special places, *e.g.*, near the hooks. Single circlet of bristles, usually 11, but any number from 9–13 has been found. Circular muscles consist of 200 bundles frequently anastomosing. Nephridia, two pairs, with spirally coiled internal openings."

This species is the most abundant Echiuroid in Japan, and is the only representative of the genus in this part of the world. The worms are known to live in shallow sandy inlets along the

Pacific coasts of Japan proper, south of the Tokyo Bay. As far as I know, they are exceedingly abundant in shallow parts of that bay, for instance, at Inage (Province of Shimosa), Haneda (Province of Musashi), and at Tateyama (Bōshū). From the last mentioned locality specimens of a large size (25 *cm.* or even 30 *cm.* in length and 3–4 *cm.* in breadth) have been obtained. Tomo (Bingo) and Hiroshima on the Inland Sea may also be mentioned as localities where this species is known to occur in great abundance.

As to the systematic characters and the microscopical anatomy of the species I have nothing to add to the exact and detailed studies of SELENKA and EMBLETON. Of much interest to me is the observation by the latter author that in the present species there is no true vascular canal at all—a fact which I have also observed independently.

Genus **THALASSEMA.**

THALASSEMA KOKOTONIENSE, FISCHER. (?)

(Fig. 17).

FISCHER (9), 1892, *p.* 2.

SHIPLEY (34), 1899, *p.* 337.

During a trip in 1901 to the Amami-Ōshima and Riukiu Islands, I collected in all 10 specimens which I provisionally

refer to the above species. In the preserved state they present nearly all the essential characters attributed to the species by FISCHER. But in the fresh state the worms were found to be of a characteristic coloration, quite different from that known from typical *T. kokotoniense*. FISCHER's description of the internal anatomy is so brief, that it does not help me much and so I must say I have considerable doubt as to the correctness of my identification of the specimens.

The body in the fresh state attains 6.5 *cm.* in length and 15 *mm.* in width, the proboscis being much shorter and narrower than the body (Fig. 17). The proboscis is straw-coloured, edged with deep green on the free margin; the body is of a grayish yellow color, its posterior end being suffused with green. When the circular muscles contract, there appear a series of longitudinal, deep red, dotted lines over the body-surface (see Fig. 17). The papillæ are larger in the posterior end of the body than in other regions, where they are arranged in transverse rows or rings on the skin.

The longitudinal muscle is always divided into 18 bundles. The segmental organs are present in three pairs; they are colorless and transparent and are all provided with two short spiral lobes. The first pair lie in front of the ventral hooks. The anal glands are one-third as long as the body-length and are fixed at their bases to the body-wall by 4-5 small muscles. Over their whole surface are scattered numerous small funnels which have very short stalks. As has been noted by FISCHER, the terminal part of the rectum bears a large rectal gland which is connected with the ventral nerve-cord by a short delicate mesentery.

Habitat: The species was found burrowing in coral sand at Naze (Amami-Ōshima) and at Naha (Riukiu).

THALASSEMA OWSTONI, N. SP.

(*Thalassema diaphanes* SLUITER.?)

(Figs. 18, 96 & 97).

The single specimen, on which this species is based, was dredged by MR. OWSTON together with the type specimen of *Phascolosoma owstoni*, from a depth of 180 fathoms in the Uraga Channel. It is small, measuring 17 mm. in length and 5 mm. in breadth. The proboscis, about 7.5 mm. long, is deeply furrowed longitudinally. The color, as preserved in formalin, is a pale reddish brown. The skin is soft and smooth, except at both extremities of the body proper, where the papillæ are largest and most closely aggregated. In the main middle region of the body the papillæ cannot be detected with the naked eye. There are two comparatively large ventral hooks of a bright yellow color.

The longitudinal muscles of the body-wall are throughout continuous. Only a pair of small sac-like segmental organs are situated just behind the ventral hooks (Fig. 96, *so*). They have no spiral appendage, but are provided with a large ciliated funnel (Fig. 97, *fn*). The erector (or the radial) muscles of the hooks are well developed (*em*, Fig. 96); the interbasal muscle is very long. Unfortunately the specimen is torn near the posterior end of the body, so that the greater part of the alimentary canal and of the anal glands has been lost. In spite of this defect it can be ascertained that there are present small ciliated funnels

on the last mentioned organs. The funnels are large, situated close together and borne on short stalks. The specimen is a female and the segmental organ of the right side is filled with ripe eggs.

The present species seems, as far as I can judge, to be most closely allied to *Thalassema diaphanes* SLUITER. I regret to say I have been unable to get access to SLUITER's original description of that species.* From what SHIPLEY (34) says of it in his revision of Echiuroids, it seems that the two species agree in having only one pair of segmental organs, in the continuous longitudinal muscle, and in wanting spiral lobes at the internal openings of the segmental organs. But the specimen in my possession shows in other points considerable deviations from SHIPLEY's description (*l.c.*, p. 336 and 346) and figure (*l.c.*, Pl. XXXIII, 2) of *T. diaphanes*, which fact has led me to base a new species on it. The most important points of difference consist in the smaller size of the body, and the thicker body-wall in the present species, and in the manner of distribution of the papillæ.

THALASSEMA TÆNIOIDES, N. SP.

A full description, with figures, of this most remarkable new species has been prepared for publication in a separate paper.† Here only the specific characters will be given in brief.

The species may be said to be of gigantic size, the body proper reaching 40 *cm.* in length and 2–3 *cm.* in breadth, while

* *Naturk. Tijdsch. Nederl. Ind.*, Vol., XLVIII, 1888.

† "On Three New and Remarkable Species of Echiuroids," soon to appear in this Journal.

the proboscis, when fully extended, is as long as 100–150 *cm.* The body proper is of a deep reddish brown color; the proboscis bears narrow transverse stripes of brown. The papillæ are irregular in shape, and are largest and most closely crowded together at both ends of the body proper. The ventral hooks are relatively small and brownish yellow in color. In the fresh state, there are seen on the body proper five narrow longitudinal stripes of a pale yellow color, corresponding to special thickenings of the longitudinal muscle. The bulbous bases of the paired hooks are joined by a slender interbasal muscle. The alimentary canal pursues a course which is peculiar to this species. The pharynx is accompanied by two large wing-like muscles. The anal glands are 6–7 *cm.* long, fixed at the apex by a long muscle; they appear to be hairy on account of the presence of very long funnels. No rectal gland is present. As the heart lies in a very posterior situation, the dorsal vessel is remarkably long. The segmental organs are extremely abundant; in the larger specimens, they may number not less than 200 on one side of the ventral nerve-cord, arranged not in pairs but apparently without order. They are small, measuring 10–12 *mm.* in length; the internal opening is terminal in position.

Habitat: The species inhabits shallow muddy bottoms in deep vertical holes, from the opening of which the long worm-like proboscis is extruded. It has hitherto been obtained at Tsushima; Bay of Amakusa (Kiushiū); Tomo and many other localities in the Inland Sea; Tateyama (Bōshiū); Haneda (Tokyo Bay); and Misaki. In the last locality the species is common.

THALASSEMA ELEGANS, N. SP.

This highly interesting species will also be fully described in a separate paper together with the preceding. Here I restrict myself to giving only the most salient characters of the species.

Externally the species looks very much alike *Thalassema tænioides*, though there exist remarkable differences in internal structure. In size, shape and color it shows a far reaching agreement with that species except as regards the proboscis. This in the present species is 30–40 *cm.* long and 1.7–2 *cm.* wide, and is of a bright yellow color which becomes deeper towards the mouth. The ventral surface of its anterior portion, for a length of 6–7 *cm.* is marked with a fine and irregular net-work of a bright green color. As in *T. tænioides*, there are found on the body-surface longitudinal stripes of a pale yellow color, which however number 10, instead of 5. The ventral hooks show nearly the same size, form, color and position as those of *T. tænioides*; but internally they are not joined by an interbasal muscle. The circular muscle of the body-wall is separated into more or less regular bundles. The segmental organs are numerous (in one specimen 27 were counted) and are distributed generally in groups of which there are 7 pairs, each consisting of 1–3 segmental organs. Aside from the pairwise arrangement indicated, there seems to obtain no definite order in the manner of the occurrence of single segmental organs. They represent large elongate sacs, each bearing two comparatively short spiral lobes. The pharynx is joined to the body-

wall, but is not accompanied by a mesenterial muscle. The anal glands are long slender tubes, about 20 *cm.* in length, and are provided with small, short-stalked funnels. No rectal gland is present.

Habitat: The species inhabits shallow muddy bottoms, in deep, somewhat obliquely sunk pits. It occurs together with *T. tænioides* in the inlet of Moroiso, close to the Misaki Marine Laboratory.

THALASSEMA GOGOSHIMENSE, N. SP.

(Fig. 19).

The present species (Fig. 19) most closely resembles *Thalassema mucosum* both in color and external shape, with the exception of the facts that the body is much larger and the papillary spots more deeply colored with a dirty green pigment. The dorsal surface of the proboscis is covered with small green spots, while its free margin is colored yellow. The total length is, in the fully extended state, about 15 *cm.* of which 10.5 *cm.* appertain to the proboscis; the maximum width, about 2 *cm.* Over the surface there are closely strewn moderately large papillæ which are slightly larger and more crowded towards both extremities of the body proper. The two ventral hooks of a golden yellow color are found in the usual situation just behind the mouth.

In spite of its external resemblance, however, this species differs remarkably from *Thalassema mucosum* in internal anatomy. In this respect it shows, contrary to expectation, an essential agreement with *Thalassema elegans*. Indeed, the agreement may be said to be complete, the only difference being that all the visceral organs in the present species are developed on a smaller scale in proportion to the smaller size of its body. It therefore seems unnecessary to give a description of the anatomy. However, certain points with regard to the segmental organs of the species require special mention. In the females, the said organs as far as they have come under my observation, are invariably present in three pairs, all situated behind the ventral hooks. On the other hand, the males show these organs in varying numbers and arrangement, a fact which seems to be of interest in relation to the polynephridism I have observed in *T. taenioides* and *T. elegans*. In one male specimen of the species I have found them in eight groups arranged pairwise, each group consisting of four organs, making thirty-two in all. In some other male individuals, the organs were present in three paired groups, some of which comprised four and others only one or two organs. As to the shape of the organs in question, there exists scarcely any difference from those of *T. elegans*.

Habitat: I have found the species very common in the shallow waters around the islet of Gogoshima (Province of Iyo). The presence of the worms is indicated by the large and peculiarly shaped faecal masses scattered around small elevations of the bottom exposed at low tide. Lately I was presented by MR. IZUKA with a specimen of this species which he obtained in the inlet of Moroiso near the Misaki Marine Laboratory.

THALASSEMA MUCOSUM, N. SP.

(Figs. 20 & 98).

Three specimens of this new species have been obtained from the muddy shore of Moroiso near the Misaki Marine Laboratory.

The cylindrical body in the live state reaches 7 *cm.* in length and 1.8 *cm.* in width; the tubular proboscis is much shorter and narrower, and has a truncated apex. The body-wall is thin and is of a light green color, which becomes deeper at both extremities and also along the margins of the proboscis. The papillæ, large enough to be visible with the naked eye, are also deep green; they are closely aggregated, especially at both ends of the body proper. In the fresh state, the body-surface always appears dirty owing to thick mucous spread over it. The two ventral hooks are small, slightly recurved and bright yellow in color. They are provided with rather short radial muscles (*em*, Fig. 98), but are devoid of an interbasal muscle. The longitudinal and circular layers of the dermal musculature are not divided into separate bundles. There are three pairs of comparatively short small segmental organs (*sg*), all of which lie behind the ventral hooks and have long spiral lobes. The pharynx (*ph*) is accompanied by two weakly developed mesenteries (*wm*) arising from the body-wall, close to the nerve-cord. The mesentery on the right side is much longer than that on the left. The neuro-intestinal vessel (*ni*), instead of being

single, appears as two vessels, which unite into one to communicate with the ventral vessel. There are two long anal glands, the anterior ends of which extend to the middle of the body; a few fine muscular strands join their posterior portions to the body-wall. The ciliated funnels of these glands are small, their stalks being very short. No rectal gland is present.

This species seems to be closely allied to both *Thalassema vegrande* LAMPERT and *T. Mæbii* GREEFF, as judged from the agreement in internal structure, but it may readily be distinguished from either. Unlike the present species, *T. vegrande* is said to be without proboscis and also without funnels on the anal glands. Of the proboscis, SHIPLEY (32) says: "Like LAMPERT I had only a single specimen, and, like his, mine had no proboscis. There was no trace of one and no scar to indicate that there had ever been one, and I am inclined to think that this species may be without a proboscis."

In contrast with *Thalassema Mæbii* the present species exhibits considerable difference in external features as a comparison of GREEFF'S (14) figure of the former with mine of the latter (Fig. 20) will show. The differences mostly concern the size, form and coloration of the proboscis as well as of the body proper.

THALASSEMA FUSCUM, N. SP.

(Figs. 21 & 99).

In external features the present species closely resembles *Thalassema mucosum*, except in color. The long cylindrical body proper is about 7.5 cm. long and 15-18 mm. thick, while

the proboscis is about 2 *cm.* long and truncated at the apex. The skin is of a slightly pinkish orange-yellow which becomes reddish on the edges of the proboscis. Large papillæ are scattered irregularly over the entire body-surface, more thickly at both ends than in the middle. The two golden-yellow ventral hooks are relatively small in size and are supplied with well developed radial muscles (*em*, Fig. 99). The longitudinal dermal muscle is perfectly continuous. There exists only one pair of comparatively long (about 20 *mm.*) segmental organs (*so*), attached to the body-wall just behind the ventral hooks. The opening of the organs appears as a large funnel (*fn*) unprovided with spiral lobes. The pharynx as well as the œsophagus are entirely without a mesentery or muscular strands. The anal glands are about as long as the body proper; the ciliated funnels, sparsely distributed over the surface, are relatively small and short-stalked. No rectal gland is present.

There have hitherto been known four *Thalassema* species which, like the present, have a continuous longitudinal muscle and only one pair of segmental organs, *viz.*, *T. diaphanes* SLUITER, *T. fax* SELENKA, *T. gigas* MÜLLER and *T. Lankesteri* HERDMAN. The first further agrees with the present species in one other point, *viz.*, that the segmental organs lack spiral lobes; nevertheless, the former shows several important characters which are entirely wanting in the latter. Of the three remaining species mentioned, *T. gigas* seems to be nearest to the present species in respect of general internal anatomy; but, that species, as figured and described in detail by GREEFF (14), should be easily distinguishable from the new species here described, owing to the differences in size, color and general features of the entire worm-body.

THALASSEMA INANSENSE, N. SP.

(Figs. 22 & 100).

A single specimen of this new species was obtained by me (1901) on a coral reef, called Inanse, about three miles off Naha (Okinawashima). It was found under a large and living Madreporite mass. The body in the fresh state was about 4.2 *cm.* long and 13 *mm.* thick, while the proboscis was about 23 *mm.* long. The latter appeared to be tubular but laterally expanded at the apex so as to present a bilobed appearance. The body proper was of a bluish violet color, spotted with small, uniformly and closely set papillæ of a dirty green color. The proboscis was yellowish gray, edged with brown on the lateral margins. The two very small ventral hooks are bright yellow.

The longitudinal muscle is continuous. There were three pairs of segmental organs (*so*, Fig. 100) filled with eggs, the most anterior pair lying in front of the ventral hooks (*hk*). The organs appear like elongate sacs and are provided with well developed spiral lobes. The anal glands (*ag*), of a brown color, are remarkably long and reach up to the level of the second pair of segmental organs. Very close to the anterior end they are joined to the body-wall by a slender muscular string. Small funnels with short stalks are sparsely distributed over the surface of the glands. The posterior terminal parts of the rectum are fixed to the body-wall by two muscles, one on each side. No rectal gland is present.

Genus **BONELLIA.****BONELLIA MINOR, MARION.**

(Figs. 23, 101 & 102).

RIETSCH (26), 1886.

SHIPLEY (34), 1899, *p.* 340.

About forty specimens of the above species were collected by me, in April, 1901, in the Riukiu Islands. The body reaches about 2 *cm.* in length and 7 *mm.* in maximum width; the proboscis is 2-2.5 times as long as the body and much narrower (Fig. 23). The color is deep green on the body and a lighter green on the proboscis; the anterior ventral portion of the body shows through the body-wall a reddish color caused by the sexual cells in the oviduct. Thus, in the color of the female the species approaches closer to *Bonellia pumicea* SLUITER (36) than to the Mediterranean specimens of *B. minor*; but the anatomy of the female as well as the general structure of the parasitic male, essentially agrees with the description and figures of the latter species given by RIETSCH except in the one point that the anal glands in the female Japanese specimens bear short branches, from each of which arise about 5-7 funnels which are relatively longer than in the Mediterranean specimens (see Fig. 101).

Fig. 102, drawn from a stained preparation, represents a male which was found in the pharynx of a female. The males

generally measure 1 *mm.* in length and 0.15 *mm.* in maximum breadth, tapering towards the posterior end. As was pointed out by RIETSCII, the skin-surface is thickly ciliated except on the dorsal side where the cuticula is comparatively thicker than in other regions. Two long and strongly curved hooks (*hk*) are present in an anterior position; behind them is seen a large spermatie reservoir (*sv*) provided with a small funnel. The duct of the reservoir begins just behind the hooks and proceeds anteriorly as a narrow tube to open at the apex of the body. This canal (*vd*) is surrounded by a nerve-ring lying just in front of the roots of the ventral hooks.

Habitat: The species is common and readily discoverable in shallow waters in the vicinity of Naha (on Okinawashima, one of the Riukiu Islands). In May, 1900, a few specimens were also collected by MR. MIYAJIMA at Kataura in the Province of Satsuma. The worms live in holes which they bore in dead corals.

BONELLIA MIYAJIMAI, N. SP.

A full description of this species together with figures, will be given in another paper which will appear in this Journal. Here will be given only the more important characters which serve to distinguish the species.

The body measures about 2 *cm.* in length and 1 *cm.* in maximum breadth, the proboscis being six times as long as the body. The color is grayish brown. The ventral hooks, instead of being present in a single pair, number 29 in all; they are arranged on the ventral surface in no definite order. The internal

opening of the unpaired oviduct is found almost at the free end of its thin-walled portion. The main canal of the anal glands divides twice before ending in funnels.

The male worm is of an unusually large size, measuring nearly 28.5 *mm.* in length and 2 *mm.* in breadth. It bears no ventral hook. The alimentary canal is found broken up into innumerable separate pieces which float free in the body-cavity. The vas deferens is internally provided with four large funnels.

Habitat: A single female of the species was discovered on breaking a dead coral, on a coral beach near Tomari, a village two miles from Naha (Okinawashima).

BONELLIA MISAKIENSIS, N. SP.

(Figs. 24, 103–105).

In July, 1896, MR. TOKUNAGA obtained the unique type specimen of this new species on the southern shore of Jōgashima, Misaki. It was found under a large stone near the beach. At the time some sketches and notes were made of the worm by the collector. MR. NISHIKAWA also made a colored sketch of the worm, which is reproduced in Fig. 24. To both gentlemen I am indebted for the material which they placed at my disposal.

According to MR. NISHIKAWA's observation on the living worm, the body proper measured 40 *mm.* in length when contracted and 60 *mm.* when fully extended; the proboscis and its arms measured respectively 50–90 *mm.* and 25–30 *mm.* in length. The proboscis as well as its arms were found to be deeply

furrowed along the midventral line. The form of the body proper was very changeable, but assumed an elongate sac-like shape when preserved. The ground color was a light grayish brown; the body proper and the greater part of the proboscis were densely marked with bluish black spots, while the lateral arms of the proboscis were of a dirty yellow color. As shown in Fig. 24, a number of slender spine-like bodies projected from the entire external surface of the worm.

In the preserved state I have been unable to find the spine-like bodies just mentioned. They had probably fallen off during the killing process; and judging from a figure of the same, drawn by MR. TOKUNAGA, it seems highly probable that they were nothing but parasitic organisms.

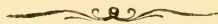
Peculiar to this species is the fact that no ventral hook is present and, consequently, no muscular sheath of the same.

Fig. 103 represents the anatomy of the specimen. The oviduct (*od*) is a sac lying on the left side of the nerve-cord, and is nearly as long as the body proper and is fully distended by the ripe eggs contained in it. Anteriorly it is greatly narrowed and its wall highly muscular, while the remaining parts are, on the contrary, much swollen and very thin-walled. The internal opening or funnel, unlike those in all other previously known *Bonellia* species, is not situated near the anterior end of the organ, but is found in the posterior terminal portion. The anal glands (*ag*) are comparatively short and are branched at least three times before ending (Fig. 104). Ten to twenty-five funnels are attached to each of the tertial branches—of course some others being attached directly to the secondary branches. Most of the branches have a fine fixing muscle joining them to the body-wall.

In the alimentary canal and the vascular system, there is no point requiring special mention.

A male worm was discovered in the anterior muscular portion of the oviduct. It is shown in Fig. 105 under low magnification ($\times 56$). Length about 3.3 *mm* ; maximum breadth 0.20 *mm*. The body narrows towards both ends. The entire surface is thickly ciliated. No ventral hook is present. There is an unpaired vas deferens (*vd*), about one-third as long the body-length. It is thickest (0.07 *mm*. across) in the posterior two-thirds of its length, ending with a relatively small funnel (*fn*). The anterior one-third is slender, running forwards through the body-cavity finally to open to the exterior. The external opening is situated not at the very tip of the body, but at a point a short distance behind it on the ventral side (x, Fig. 105). The alimentary canal is found in a state of degeneration similar to that observed in the male of *Bonellia miyajimai*. It does not form a continuous tube, but is broken up into about ten small pieces of different lengths and sizes (*pa*, Fig. 105). These pieces are scattered in the body-cavity, being apparently in no definite relation to one another. The blood corpuscles and sperm-masses are found in abundance, both floating free in the body-cavity.

As to further details of the histology of the male, I have been unable to obtain definite results, owing to the imperfect preservation of the specimen.



**Key to the Genera and Species of Gephyrea treated
of in this Paper.**

Sipunculoidea.

- I.** The longitudinal muscle of the body-wall is divided into 15-31 separate bundles. Two or four retractor muscles present.
- A.**—Body covered with well developed papillae. Hooks usually present on the introvert. Filamentous tentacles arranged in a single semicircle above the mouth. Retractor muscles commonly in two pairs (except in two species, *Phymosoma ono-michianum* and *Phymosoma nahaense*, both which are characterised by having only two muscles). No rectal gland, no ventral vessel. Two distinct eye-spots on the ganglion.....
.....*Genus* PHYMOSOMA. P. 78.
- B.**—Body devoid of papillae. Tentacles filamentous or flap-like, in the latter case they spring from the tentacular membrane. Hooks usually absent. Rectum with one or more caeca. Usually a ventral vessel in addition to the dorsal vessel. No eye-spot*Genus* SIPUNCULUS. P. 79.
- II.** The longitudinal muscle of the body-wall is perfectly continuous.
- A.**—Two segmental organs and a spindle muscle present.
- a.**—Numerous tentacles. Spindle muscle is sometimes fixed posteriorly to the body-wall. Usually two pairs of retractor muscles.
.....*Genus* PHASCOLOSOMA. P. 79.
- b.**—Tentacles spring from four main stems. Hooks, if present, large, but few and scattered. Spindle muscle posteriorly free from the body-wall. Only one pair (ventral) of retractor muscles.
.....*Genus* DENDROSTOMA. P. 80.
- B.**—Only one segmental organ; spindle muscle wanting.
- c.**—Numerous tentacles arranged in a circle round the mouth. Two retractor muscles. The worms belonging to this genus inhabit Molluscan shells.
.....*Genus* PHASCOLION. P. 80.

III. At both ends of the body proper, a horny or calcareous shield. Hooks present. Longitudinal muscle continuous. Only two retractor muscles (fused together generally from their origin).

a.—A horny (rarely more or less calcareous) shield at both ends of the body proper. The introvert is excentric, arising from the ventral side of the anterior or anal shield. Tentacles few and arranged in a single semicircle....*Genus* ASPIDOSIPHON. *P.* 81.

b.—A spiral series of calcareous papillæ forms the anal shield; the posterior, or caudal, shield is wanting. The introvert is extruded from the centre of the anal shield.*Genus* CLÆOSIPHON. *P.* 81.

PHYMOSOMA.

I. 4 retractor muscles.

A.—Dorsal vessel devoid of contractile villi. No collar-like skin-fold behind tentacles.

a.—A single bifurcated fixing muscle. Tentacles about 12. The longitudinal muscle divided into 20–21 bundles. Crescent-shaped markings on the dorsal side of introvert.*P. scolops.* *P.* 20.

b.—Fixing muscle single and simple.

1.—Tentacles about 28. The longitudinal muscle separated into about 30 bundles. Papillæ prominent. Segmental organs long and accompanied by a mesentery along their entire length.*P. japonicum.* *P.* 22.

2.—Tentacles 35–40. Longitudinal muscles, 30–35. Papillæ remarkably prominent. Segmental organs short and accompanied by a mesentery along the anterior half of their length.
.....*P. pacificum.* *P.* 25.

B.—Dorsal vessel with contractile villi. A collar-like fold behind tentacles.

Tentacles very numerous (50–80). Papillæ small and low. Longitudinal muscle varying in the number of bundles....*P. antillarum.* *P.* 24.

II. 2 retractor muscles.

- a.*—Hooks provided with one apical tooth. Dorsal vessel devoid of contractile villi.....*T. nahagense*. P. 29.
b.—Hooks wanting. Papillæ prominent. Contractile villi numerous and ramified.....
*T. onomichiannum*. P. 26.

SIPUNCULUS.

- A.**—Tentacles flap-like. The chitin over the body proper folded into rectangular areas. Introvert with very tall, posteriorly directed papillæ. Longitudinal muscle separated into 31 bundles.....*S. nudus*. P. 31.
B.—Tentacles filamentous. Body-surface shows no rectangular areas. Introvert and body proper covered with skin-bodies.
a.—Longitudinal muscles 18–21. Crescent-shaped dissepiments on the inner side of the body-wall. With a bifurcated fixing muscle....*S. eumanensis*. P. 32.
b.—Longitudinal muscles 15. Devoid of crescent-shaped dissepiments. Fixing muscles 2.....
*S. amamiensis*. P. 38.

PHASCOLOSOMA.

I. 2 retractor muscles.

No hook. Introvert long. Body as a whole coiled into a spiral.....*P. nigrum*. P. 3.

II. 4 retractor muscles.**A.**—With hooks and 1–2 fixing muscles.

- a.*—Hooks provided with 4–5 small accessory teeth and arranged in ring-rows. A single fixing muscle. Segmental organs consist of two elongate lobes directed oppositely.*P. misakianum*. P. 7.
b.—A somewhat larger form. Hooks dispersed, almost straight, and devoid of accessory teeth. 2 fixing muscles. Segmental organs of an ordinary shape....
*P. owstoni*. P. 12.

B.—No hooks; with 3 fixing muscles.

a.—Eye-spots present. No respiratory apparatus on the body proper. Littoral form. ... *P. japonicum*. *P.* 5.

b.—Eye-spots wanting. Respiratory apparatus present over the surface of the body proper. Deep-sea form. *P. okinoseanum*. *P.* 9.

DENDROSTOMA.

I. Hooks generally wanting.

A dark-blue marking at the middle of the introvert. 3 fixing muscles. Contractile villi numerous, long and branched. Spindle muscle posteriorly free from the body-wall.
..... *D. signifer*. *P.* 56.

II. Hooks present.

A.—Tentacles short but very numerous. Hooks very large (0.20 *mm.* high). Contractile villi few, but remarkably long. 3 or 4 fixing muscles. *D. blautum*. *P.* 53.

B.—Tentacles relatively long, about 8–12 of which branch off from one of the 4 main stems. Hooks small (0.04–0.06 *mm.* high) and about 50 in number. Contractile villi short and numerous. Fixing muscles indefinite in number (0–3).
..... *D. minor*. *P.* 57.

PHASCOLION.

I. Body straight. Papillary bodies are in general small and the middle part of the body proper seems almost smooth. A single retractor muscle with two short roots. 4 fixing muscles.

..... *P. rectus*. *P.* 15.

II. Body coiled into a spiral. The middle part of the body proper covered with especially large papillæ. 2 retractor muscles, one of which is much more slender than the other. No fixing muscle. *P. artificiosus*. *P.* 18.

ASPIDOSIPHON.

- I.** Skin-papillæ distinct. A single fixing muscle and a rectal gland present.

A.—Both anal and caudal shields present.

a.—The two shields radially grooved.

1.—Longitudinal muscle separated into very irregular bundles. Retractor muscles arise from the inside of the caudal shield....*A. truncatus*. P. 38.

2.—Longitudinal muscle separated into more or less regular bundles. Retractor muscles arise far anterior to the caudal shield....*A. steenstrupii*. P. 40.

b.—The peripheral border of the anal shield only is lightly grooved.

Longitudinal muscle continuous. Retractor muscles arise just in front of the caudal shield.

.....*A. misakiensis*. P. 41.

B.—Caudal shield indistinct.

The anal shield is of the shape of a tall, obliquely directed cone; it is very thick and calcareous, and its surface roughened by the presence of distinct radial ridges and grooves....

.....*A. uniscutatus*. P. 43.

- II.** No papillæ over the greater part of the body proper. No fixing muscle or rectal gland.

a.—The two shields show a prominent circular ridge, on both sides of which are present longitudinal ridges and grooves. Hooks have a bluntly pointed apex. No fixing muscle or rectal gland.

.....*A. angulatus*. P. 45.

b.—The two shields show a granular appearance. Hooks two-toothed at apex. The greater part of the introvert-surface covered with scattered spines....

.....*A. spinolis*. P. 47.

CLOESIPHON.

- Only one species is known in this country.....*C. japonicum*. P. 49.

Echiuroidea.

- I.** Proboscis not bifurcated at apex, but truncated transversely. Sexes of similar appearance.
- A.**—Anal hooks arranged in 1 or 2 circles. 2 pairs of segmental organs. *Genus* ECHIURUS. P. 82.
- B.**—No anal hook. 1-3 pairs or more of segmental organs.....
..... *Genus* THALASSEMA. P. 82.
- II.** Proboscis bifurcated at apex. Sexual dimorphism remarkably pronounced.
- No anal hook. Unique segmental organs.....
.. *Genus* BONELLIA. P. 83.

ECHIURUS.

Anal hooks arranged in a single circle. No definite blood vessel.
..... *E. uncinatus*. P. 59.

THALASSEMA.

- I.** Longitudinal muscle continuous.
- A.**—Segmental organs in only one pair; the internal openings of the organ lack spiral lobes.
- a.**—Body of a small size. Ventral hooks provided internally with a well developed interbasal muscle....
..... *T. owstoni*. P. 62.
- b.**—Skin-papille prominent over the whole surface. No interbasal muscle. *T. fuscum*. P. 69.
- B.**—Segmental organs in 3 pairs; provided with spiral lobes.
- a.**—The anteriormost pair of segmental organs lie in front of the ventral hooks. *T. inansense*. P. 71.
- b.**—All segmental organs lie behind the ventral hooks.
..... *T. mucosum*. P. 68.

C.—Segmental organs indefinite in number, always more than 3 pairs.

a.—Segmental organs very numerous, small and not provided with spiral lobes. Proboscis remarkably long. *T. tenioides*. P. 63.

b.—Segmental organs grouped commonly into 7 pairs, each group consisting of 0-3 large organs; they are provided with spiral lobes. Proboscis nearly as long as body. *T. elegans*. P. 65.

c.—Segmental organs, in the female, in 3 pairs, while in the male they are found in 6 or 8 groups arranged pairwise, each group consisting of 1-4. The shape of the organs is like that of *P. elegans*. *T. gogoshimense*. P. 66.

II. Longitudinal muscle divided into 18 broad bundles.

Segmental organs in 3 pairs, the anteriormost pair being situated in front of the ventral hooks; they are provided with short spiral lobes. A large rectal gland present. *T. kokotoniense*(?) P. 60.

BONELLIA.

I. Very numerous ventral hooks in the female and no hook in the male.

The female worm bears a grayish brown color; a large form. Parasitic male of a remarkably large size.
..... *B. miyajimai*. P. 73.

II. No ventral hook in either sex.

The female of a grayish brown color, spotted with a deep bluish black pigment. *B. misakiensis*. P. 74.

III. Two ventral hooks present in both sexes.

Color bright green on body and pale green on proboscis. A small form, living in dead corals.... *B. minor*. P. 72.

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to me in working out the present study.**

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List of Abbreviations used in the plates.

<i>a.</i> , Anus.	<i>nc.</i> , Nerve-cord.
<i>ag.</i> , Anal gland.	<i>ni.</i> , Neuro-intestinal vessel.
<i>b.</i> , Transverse bar of hook.	<i>ol.</i> , Oviduct.
<i>cv.</i> , Contractile villi.	<i>oe.</i> , Œsophagus.
<i>dm.</i> , Dorsal muscle.	<i>pa.</i> , Pieces of digestive canal.
<i>dv.</i> , Dorsal vessel.	<i>ph.</i> , Pharynx.
<i>em.</i> , Erector (or radiating) muscle of ventral hook.	<i>rg.</i> , Rectal gland.
<i>fm.</i> , Fixing muscle.	<i>rt.</i> , Reticular tissue.
<i>fn.</i> , Ciliated funnel.	<i>w.</i> , Warts or 'Runzeln.'
<i>g.</i> , Ganglion.	<i>sm.</i> , Spindle muscle.
<i>hk.</i> , Hook.	<i>so.</i> , Segmental organ.
<i>ht.</i> , Heart.	<i>sr.</i> , Spermatoc reservoir.
<i>ic.</i> , Intestinal convolution.	<i>so.</i> , Sexual organ.
<i>im.</i> , Interbasal muscle of ventral hook.	<i>vl.</i> , Vas deferens.
<i>m.</i> , Mesentery.	<i>vm.</i> , Ventral muscle.
<i>mf.</i> , Muscle-fibres.	<i>wm.</i> , Wing-like muscle.

I. IKEDA.

THE GEPHYREA OF JAPAN.

PLATE I.

- Fig. 1.—*Phascolosoma nigrum*, n. sp. Natural size.
Fig. 2.—*Phascolosoma japonicum*, n. sp. Natural size.
Fig. 3.—*Phascolosoma misakianum*, n. sp. About 7 times enlarged.
Fig. 4.—*Phascolosoma okinoseanum*, n. sp. Natural size.
Fig. 5.—*Phascolosoma owstoni*, n. sp. Natural size.
Fig. 6.—*Phascolion artificiosus*, n. sp. About 10 \times .
Fig. 7.—*Phymosoma onomichianum*, n. sp. Natural size.
Fig. 8.—*Phymosoma nahaense*, n. sp. Natural size.
Fig. 9.—*Aspidosiphon misakiensis* n. sp. 2 \times .
Fig. 10.—*Aspidosiphon uniscutatus*, n. sp. Greatly magnified.
Fig. 11.—*Aspidosiphon angulatus*, n. sp. 10 \times .
Fig. 12.—*Aspidosiphon spinalis*, n. sp. 3 \times .
Fig. 13.—*Oliosiphon japonicum*, n. sp. Natural size.
Fig. 14.—*Dendrostoma blandum*, Sel. and De Man. Natural size.
Fig. 15.—*Dendrostoma signifer*, Sel. and De Man. Natural size.
Fig. 16.—*Dendrostoma minor*, n. sp. 5 \times .
Fig. 17.—*Thalassema kokotoniense*, Fischer (?). Natural size.
Fig. 18.—*Thalassema owstoni*, n. sp. 2 \times .
Fig. 19.—*Thalassema gogoshimense*, n. sp. Natural size.
Fig. 20.—*Thalassema mucosum*, n. sp. Natural size.
Fig. 21.—*Thalassema fuscum*, n. sp. Natural size.
Fig. 22.—*Thalassema inansense*, n. sp. Natural size.
Fig. 23.—*Bonellia minor*, Marion. Natural size.
Fig. 24.—*Bonellia misakiensis*, n. sp. Natural size.



I. IKEDA.

THE GEPHYREA OF JAPAN.

PLATE II.

Phascolosoma nigrum.

Fig. 25.—A papilla from the posterior body region. 180 ×.

Eig. 26.—A papilla from the introvert. 180 ×.

Fig. 27.—A specimen dissected.

Phascolosoma japonicum.

Fig. 28.—Skin with chitinous bodies from the middle body region. 265 ×.

Fig. 29.—A specimen dissected.

Phascolosoma misakianum.

Fig. 30.—A papilla from the posterior body end; *a* in longitudinal optical section and *b* in surface view. 180 ×.

Fig. 31.—A perforated papilla from the introvert. 410 ×.

Fig. 32.—A hook from the introvert; side view. 410 ×.

Fig. 33.—A specimen dissected.

Phascolosoma okinoseanum.

- Fig. 34.—A papilla from the posterior body end. Zeiss Oc. 2 and Obj. Imm. $\frac{1}{12}$.
Fig. 35.—Papillæ from the introvert basis. 180 \times .
Fig. 36.—A sac-like respiratory organ on the skin. 65 \times .
Fig. 37.—Basal part of the same. Zeiss Oc. 2 and Obj. Imm. $\frac{1}{12}$.
Fig. 38.—A specimen dissected.

Phascolosoma ourstoni.

- Fig. 39.—A papilla from the posterior body region. 180 \times .
Fig. 40.—A papilla from the introvert basis. 180 \times .
Fig. 41.—A papilla from the introvert. 180 \times .
Fig. 42.—A hook from the introvert. 180 \times .
Fig. 43.—A specimen dissected.
Fig. 44.—Magnified surface-view of the peculiar reticular structure on the inside of the body-wall. Zeiss Oc. 3 and Obj. a₂.

Phascolion rectus.

- Fig. 45.—The whole worm-body. 2 \times .
Fig. 46.—Papillæ from the middle parts of the introvert. 330 \times .
Fig. 47.—Papillæ and chitinous thickenings of the skin at the introvert-basis. 200 \times .
Fig. 48.—Papillæ from the posterior end of body. 330 \times .
Fig. 49.—Specimen dissected.

Phascolion artificiosus.

- Fig. 50.—Gastropod shell containing the worm. 2 \times .
Fig. 51.—Large papillæ seen from above. 200 \times .
Fig. 52.—Small papillæ from the middle region of the introvert. 330 \times .



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THE GEPHYREA OF JAPAN.

PLATE III.

Phascolion artificiosus (continued).

- Fig. 53.—Papillæ from the posterior end of body. 200 \times .
Fig. 54.—Finger-shaped papillæ from the basis of the introvert. 200 \times .
Fig. 55.—A specimen dissected.

Phymosoma onomichianum.

- Fig. 56.—A papilla from the middle body region. 180 \times .
Fig. 57.—A papilla from the introvert-basis; *a* side view; *b* surface view. 180 \times .
Fig. 58.—Specimen dissected.

Phymosoma nahaense.

- Fig. 59.—A papilla from the middle body region. 265 \times .
Fig. 60.—A hook from the introvert; side view. 265 \times .
Fig. 61.—A perforated papilla of the introvert; side view. 265 \times .
Fig. 62.—A specimen dissected.

Sipunculus cumanensis.

- Fig. 63.—Portion of a transverse section through the body-wall, showing the structure of the 'ovale Gebilde.'

Sipunculus amamiensis.

- Fig. 64.—A papilla from the middle body region; surface view. 294 \times .
Fig. 65.—A specimen dissected.

Aspidosiphon truncatus.

- Fig. 66.—A hook from the introvert; side view. 410 \times .
Fig. 67.—A perforated papilla from the introvert; side view. 410 \times .

Aspidosiphon misakiensis.

- Fig. 68.—Anterior end of body, showing the anal shield. 20 \times .
Fig. 69.—A hook; side view. 600 \times .
Fig. 70.—One of the spines found scattered on the introvert; side view. 600 \times .
Fig. 71.—A perforated papilla lying between hook-rows. 294 \times .
Fig. 72.—A specimen dissected.

Aspidosiphon uniscutatus.

- Fig. 73.—Magnified view of the basal parts of a longitudinal ridge of the anal shield. 95 \times .
Fig. 74.—A papilla from the middle body region. 410 \times .
Fig. 75.—A hook from the hook-rows; side view. 680 \times .
Fig. 76.—A perforated papilla lying between the hook-rows. 680 \times .
Fig. 77.—A specimen dissected.

Aspidosiphon unguulatus.

- Fig. 78.—A papilla from the posterior body-region; surface view. 265 \times .
Fig. 79.—Hooks and perforated papillæ from the introvert. 410 \times .
Fig. 80.—A specimen dissected. (This figure has been inserted in Pl. III).

Aspidosiphon spinulatus.

- Fig. 81.—A papilla lying near the caudal shield; surface view. 265 \times .



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PLATE IV.

(For explanation of Fig. 80, see under Pl. III.)

Aspidosiphon spinalis (continued).

- Fig. 82.—One of the spines scattered on the introvert. 294 \times .
Fig. 83.—A hook from the ring-rows on the introvert; side view. 294 \times .
Fig. 84.—A perforated papilla from the introvert; side view. 294 \times .
Fig. 85.—Specimen dissected.

Clavosiphon japonicum.

- Fig. 86.—Magnified view of the calcareous shield. Zeiss Oc. 2 and Obj. aa.
Fig. 87.—A papilla from the middle body region; surface view. 410 \times .
Fig. 88.—A papilla from the introvert-basis; side view. 180 \times .
Fig. 89.—A hook and a perforated papilla from the introvert. 410 \times .

Dendrostoma blandum.

- Fig. 90.—Side view of the main stems of tentacles. 20 ×.
Fig. 91.—Magnified view of a portion of the digestive canal, showing the rectal gland (*rg*), the fixing muscles (*fm*), etc. 5 ×.

Dendrostoma minor.

- Fig. 92.—A papilla from the posterior body end; surface view. 294 ×.
Fig. 93.—Side view of a papilla from the hooked region of the introvert. 265 ×.
Fig. 94.—One of the scattered hooks of the introvert. 410 ×.
Fig. 95.—A specimen dissected.

Thalassema orstoni.

- Fig. 96.—Specimen dissected; the greater part of the digestive canal is cut off. 3 ×.
Fig. 97.—Magnified figure of a segmental organ.

Thalassema mucosum.

- Fig. 98.—Magnified view of a dissected specimen, showing only the anterior body end.

Thalassema fuscum.

- Fig. 99.—Magnified view of a dissected specimen, showing only the anterior body end.

Thalassema inansense.

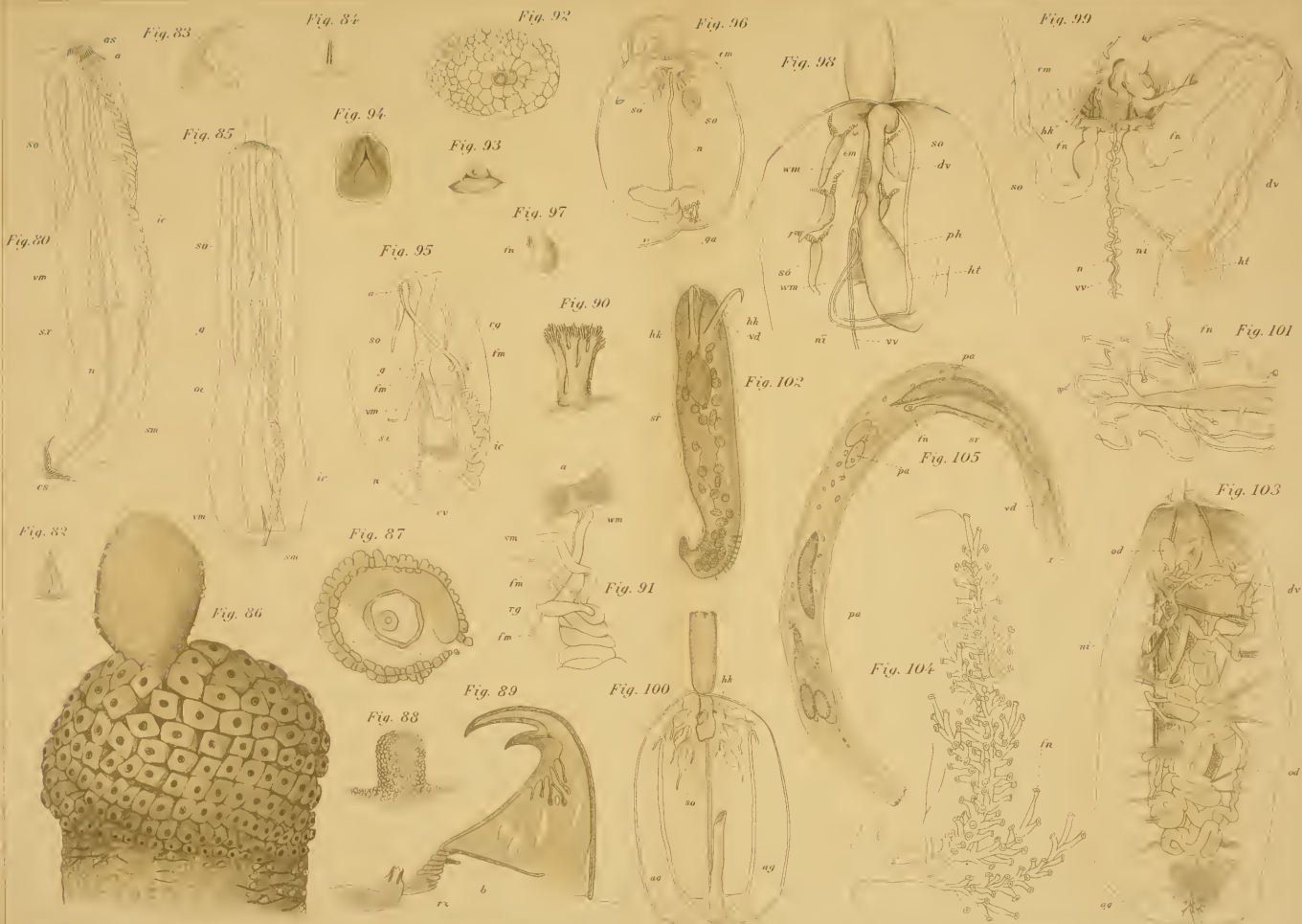
- Fig. 100.—Specimen dissected; the greater part of the digestive canal is cut off.

Bonellia minor.

- Fig. 101.—Distal portion of an anal gland of the female. 20 ×.
Fig. 102.—Male worm, drawn from a stained toto preparation. 131 ×.

Bonellia misakiensis.

- Fig. 103.—Specimen dissected, all internal organs *in situ*. 2 ×.
Fig. 104.—One of the secondary branches of the anal gland. Highly magnified.
Fig. 105.—Male worm, drawn from a stained toto preparation. 56 ×.



Mesozoic Plants from Nagato and Bitchu.

By

Matajiro Yokoyama, *Rigakuhakushi*.

Professor of Palaeontology, Imperial University of Tokyo.

With 3 plates.

1. Plants from Nagato.

Some fourteen years ago, I wrote a brief paper¹⁾ on fossil plants discovered by Dr. T. KOCHIBE at Yamanoi, in the Province of Nagato, in which I advanced the opinion that they were most probably Rhætic in age. This view is now entirely confirmed by my recent study of a later collection made by Mr. K. INOUE at the same place. This collection, although not rich in the number of species, contains specimens which are valuable both as supplementing those previously found only in an imperfect state, and as making possible a determination of the exact age of the layer in which they were obtained.

The plant-bearing formation of Yamanoi is below the so-called *Inkstone Series* with which it was formerly incorporated. The lower part of the latter has been recently proved by me to be Liassic²⁾ from the Ammonites entombed in it. The former

1) On Some Fossil Plants from the Coal-bearing Series of Nagato. Journal of the College of Science, Imperial University, Japan, Vol. IV, part, II, 1891.

2) Jurassic Ammonites from Echizen and Nagato. Ibid., vol. XIX, art. 20, 1904.

contains anthracite layers in its lower portion, and is underlaid by a marine limestone filled with *Fusulina*.

The species of clearly determinable plants which I can now mention from Yamanoi are the following :

1. *Cladophlebis nebbensis* (BRGNT.)
2. *Cladophlebis yamanoiensis* YOK.
3. *Dictyophyllum Nathorsti* ZEIL.
4. *Dictyophyllum japonicum* YOK.
5. *Dictyophyllum Kochibei* YOK.
6. *Podozamites lanceolatus* (LINDL. ET HUTT.)
7. *Nilssonia Inouyei* YOK.
8. *Baiera paucipartita* NATH.

Among these, *Cladophlebis nebbensis* and *Cl. yamanoiensis* are what I formerly called *Asplenium Ræsserti* PRESL, and *Asp. Ræsserti* var. *whitbiensis* BRGNT. respectively, while *Dictyophyllum Nathorsti* is a species which I formerly compared to *D. acutilobum* BRAUN.

It may be here added, that among the plants brought back by Mr. INOUE, there are fragments which seem to be referable to the genera *Pinus* and *Phœnicopsis*, but which are at present still undetermined.

A glance at the above list shows the indubitable Rhætic nature of the florula. The three species, *Cladophlebis nebbensis*, *Dictyophyllum Nathorsti* and *Baiera paucipartita*, are forms hitherto known only from the Rhætic. *Podozamites lanceolatus* is indeed a form of wide occurrence in the Jurassic, but its first appearance seems to be in the Rhætic. The remaining species being those found only in Japan are not available for the determination of the age. But we must remember that a form like *Dictyophyllum japonicum* exhibits a great resemblance to one

already found in the Rhætic of Europe. Therefore we may safely conclude that at least the upper portion of the plant-bearing series of Yamanoi belongs to the uppermost Keuper, or Rhætic as it is generally called.

DESCRIPTION OF THE SPECIES.

1. **CLADOPHLEBIS NEBBENSIS** (BRGNT.).

Pl. I. Fig. 1-3.

Cladophlebis nebbensis NATHORST, *Bidrag till Sveriges fossila Flora*, p. 16, pl. II, fig. 1-6, pl. III, 1-3. MÖLLER, *Bidrag till Bornholms fossila Flora, Pteridofyter*, p. 29, pl. II, fig. 22, pl. III, fig. 1. ZEILLER, *Flore Fossile des Gîtes de Charbon du Tonkin*, p. 45, pl. IV, fig. 2-4.

Pecopteris nebbensis BRONGNIART, *Histoire des Végét. Foss.*, p. 299, pl. XCVIII, fig. 3.

Asplenium Ræsserti YOKOYAMA, *On Some Fossil Plants from the Coal-bearing Series of Nagato*, p. 241, pl. XXXII, fig. 1-5.

This fern which I formerly took for *Cladophlebis* (*Asplenium*) *Ræsserti* (PRESL.), a well known Rhætic form, proved to be a different, but still very closely related species of the same formation, viz. *Cladophlebis nebbensis* (BRGNT.), as has already been pointed out by ZEILLER in his excellent work on the fossil flora of Tonkin, above cited. This author who studied specimens of both species occurring in Tonkin says that the pinnules of *Cladophlebis nebbensis*, besides being denticulated at least in the posterior and middle portions of the frond, are generally larger and broader, with apex more rounded and margins more parallel than those of *Cladophlebis Ræsserti*. He adds moreover that in

the former the two basal pinnules of every pinna, one in front of the rachis and the other behind it are different either in shape or in mode of attachment to it, a character never observed in the latter. Lastly it is said that the lateral veins of the pinnules of BRONGNIART's species are more divergent, further apart, and less divided than those of the pinnules of Presl's species.

Although none of the specimens found at Yamanoi show denticulated pinnules, yet the other characters, especially the peculiarity in the two basal pinnules, being observable in them the plant is now referred to the species first created by Brongniart.

Very frequent, but mostly fragmentary.

2. **CLADOPHLEBIS YAMANOIENSIS** YOK.

Asplenium Rœsserti var. *whitbiensis* YOKOYAMA, *On Some Fossil Plants from the Coal-bearing Series of Nagato*, p. 242, pl. XXXII, fig. 3, 3a, 4.

Fronde bi-or tripinnate. Principal rachis moderately strong and rigid. Pinnæ elongated, linear, alternate, slightly inclined forward, rather widely separated so that there is more or less space left between them. Pinnules falcate, those on the posterior side of the pinnæ being especially so, and also more strongly inclined forward than those on its anterior side, alternate, close together, but separate to the base, bluntly pointed, thin in texture. Midrib distinct, but diffusing into branches toward the end. Lateral veins going off obliquely at a very wide angle, divergent, forking twice, except near the end where they are forked only once.

Although I formerly identified this fern with *Cladophlebis whitbiensis* BRGNT., the strong forward inclination of the pinnules

of the posterior side of the pinnæ compells me to treat it now as a new species. In the form and venation of the pinnules, our specimens show a close resemblance to those figured and described by HEER as *Asplenium whitbiense* var. *tenuis* (*Beitr. z. Juraflora Ostsib. u. d. Amurl.*, p. 39, pl. III, fig. 3) from Siberia, which, however, have the pinnæ so close together as to partly overlap one another. A plant described under the same name from the Jurassic of China (*Schenk* in RICHTHOFEN's *China*, vol. IV, pl. LIII, fig. 1) has the pinnæ further apart, but the veins are somewhat denser, and moreover there is not the peculiarity of the posterior pinnules before mentioned.

Specimens of this plant are not found in the collection of Mr. INOUE. Therefore the only ones which are at hand are those formerly figured by me in the work above cited. For this reason the figures are not given here.

3. **DICTYOPHYLLUM JAPONICUM** YOK.

Pl. II. Fig. 3.

Dictyophyllum japonicum YOKOYAMA, *On Some Fossil Plants from the Coal-bearing Series of Nagato*, p. 243, pl. XXX.

Among the specimens collected by Mr. INOUE, there is a fragment of a basal portion of a frond in which the more or less palmate nature of the pinnæ is well shown. As may be seen from our figure, the primary rachis is divided apparently into two very divergent branches, each carrying on its upper or front side several pinnæ which are separated from one another by a short space and assume a more less fan-shaped appearance.

Very frequent.

4. **DICTYOPHYLLUM NATHORSTI** ZEILLER.

Dictyophyllum Nathorsti ZEILLER, *Flore Fossile des Gîtes de Charbon du Tonkin*, p. 109, pl. XXIII, fig. 1, XXIV, 1, XXV, 1-6, XXVI, 1-3, XXVII, 1, XXIII, 3.

Dictyophyllum cf. *acutilobum* YOKOYAMA, *On Some Fossil Plants from the Coal-bearing Series of Nagato*, p. 242, pl. XXXII, fig. 6.

No specimen of this plants being found in the INOUE collection, I am again obliged to refer to the one previously figured by me in the work above cited.

At that time, I had called attention to the fact that the teeth in the frond of the Japanese specimen are closer together than in most of the figures of *D. acutilobum* (BRAUN), given by SCHENK and others. And now I am quite convinced that our plant is identical with *D. Nathorsti*, a species recently created by ZEILLER for specimens from Tonkin which he also formerly took for those of BRAUN's species. A glance at plate XXV of ZEILLER's work will show to a certainty that the Japanese and the Indo-Chinese plants belong to one and the same form.

5. **DICTYOPHYLLUM KOCHIBEI** YOK.

Pl. I. Fig. 5, 7. Pl. II. Fig. 1, 2.

Dictyophyllum Kochibei YOKOYAMA, *On Some Fossil Plants from the Coal-bearing Series of Nagato*, p. 244, pl. XXIV, fig. 1, 1a.

The diagnosis formerly given of this species may be revised as follows :

Primary pinnæ elongated, deeply pinnatifid. Secondary pinnæ elongated, mostly inclined a little forward, but sometimes going off from the rachis nearly at right angles, rigid or slightly bent forward or even a little flexuous, mostly separated from one another by a greater or less interval, alternate or subopposite, gradually diminishing in length toward the front, until at last they become mere lobes of the primary pinnæ, lobed. Lobes in the posterior pinnæ ovate or ovately lanceolate with very deep incisions between them, crenate at margin, obtusely pointed at apex, while those in the anterior pinnæ become shorter, with shallower incisions, entire and more blunt, so that in the most anterior ones they change into mere crenations and then finally disappear. Rachis of the primary as well as of the secondary pinnæ slender. Midrib of the lobes distinct, but weak, somewhat zigzag, evanescent. Lateral veins forming polygonal nets within which there are still smaller ones. Veins in the lobed wings similar to those of the lobes of the pinnæ. Fertile pinnæ like sterile ones, with numerous, crowded, more or less rounded sori on the finer veins.

When I first described this species, I had only a single piece of stone on which was preserved a part of two consecutive pinnæ which I then took for the primary ones. But now on examining the excellent specimens collected by Mr. INOUE, I find them to be the secondary pinnæ which belong to the posterior portion of the frond. Figs. 5 and 7 in pl. I represent secondary pinnæ probably belonging to the middle portion of a primary pinna, while fig. 1, pl. I shows its terminal portion.

This plant seems to be not so rare, as was at first supposed.

6. **PODOZAMITES LANCEOLATUS** (LINDL. ET HUTT.)

Pl. I. Fig. 6.

Podozamites lanceolatus YOKOYAMA, *On Some Fossil Plants from the Coal-bearing Series of Nagato*, p. 245, pl. XXXIV, fig. 3, 4.

Podozamites distans ZEILLER, *Flore Foss. d. Gîtes d. Charb. d. Tonkin*, p. 159, pl. XLII, fig. 1-4. *Nathorst, Beitr. z. foss. Flora Schwedens*, p. 23, pl. XIII, fig. 1-6, XV, 20.

Zamites distans SCHENK, *Flora der Grenzschiefer*, pl. XXXV, fig. 10, XXXVI.

Specimens belonging to this well known form of *Podozamites* are quite frequent at Yamanoi, though mostly in a fragmentary state. The one shown in our figure has the leaflets attached to the rachis. Judging from their shape, the plant seems to belong to the variety *genuina* of HEER.

ZEILLER is of opinion that the Rhætic *Podozamites distans* (PRESL) should be kept separate from *P. lanceolatus* (LINDL.) of the Middle Jurassic, on the ground that they belong to two different geological horizons. Indeed it is quite true that, similar as they are, they may possibly be two different species. But in a case like this, in which the determination must be based upon the leaves alone in which the two species present no marked differences, their union is not at all unjustifiable, especially when we consider that some of the plant fossils are remarkable for their longevity. One instance of this is found in our *Onychiopsis elongata* (GEYL.) which is not only abundant in our Lower Oolite, but also in our Neocomian. Recently it has even been suspected that it occurs also in the Lias.

7. **NILSSONIA INOUEI** YOK.

Pl. I. Fig. 4. Pl. II. Fig. 4.

Leaf elongated, narrow, sides nearly parallel, 8–12 mm broad, entire, bluntly pointed at apex. Midrib more or less straight, moderately strong. Lateral veins fine, straight, parallel, dense, slightly inclined forward.

This species first found by Mr. INOUE is represented by only a few specimens. Fig. 4, pl. II shows one which, though not quite complete, illustrates the general character of a leaf. It is about 12 mm at the broadest part, tapering very slightly toward front and back. Fig. 4, pl. I represents a part of a narrower leaf.

The species exhibits a great resemblance to *Nilssonia ozoana* YOK. (*Jurassic Plants from Kaga, Hida and Echizen*, p. 42, pl. X, fig. 2b, 11–14). But the veins are coarser, there being 2–3 to a millimeter, while in the latter we can count 4 such in the same space.

8. **BAIERA PAUCIPARTITA** NATH.

Pl. II. Fig. 5.

Baiera paucipartita NATHORST, *Om Floran i Skanes Kol-förande Bildningar I. Floran vid Bjuf*, p. 94, pl. XX, fig. 7–13, XXI, XXII, 1–2.

Baiera ? sp. YOKOYAMA, *On Some Fossil Plants from the Coal-bearing Series of Nagato*, p. 246, pl. XXXIV, fig. 6.

What I had formerly suspected to be a *Baiera* proved, not only to belong to that genus, but also to a form already

known from the Rhætic of Sweden. The specimen shown in our figure is the best we have. It is a leaf composed of several, narrow, parallel-sided lobes which are obtuse at apex and arranged in a fan-shaped manner. The breadth of the lobes reaches 5 mm, in which space we can count 7 or 8 fine, parallel veins.

Not rare, but mostly in small fragments.

2. Plants from Bitchu.

The neighbourhood of Nariwa, a little town in the province of Bitchu, has long been known as one of the localities of *Pseudomonotis ochotica* KEYS., a bivalve peculiar to the Alpine facies of the Upper Triassic.

The order of rock-layers observed at this place and believed to belong to the Mesozoic formation, when counted from below, is as follows :

1. *Sandstone*, grey, fine-grained, often argillaceous and then darker-coloured, containing innumerable remains of *Pseudomonotis ochotica* which is almost the only fossil ever found in this layer.

2. *Sandstones and Shales*, alternating with each other. The former is similar in character to No. 1, while the latter is often coaly and black, and contains impressions of vegetable remains. In this complex, there are two anthracite layers near Nariwa, each a foot in thickness.

3. *Schalstein*, red to dark red, very fine-grained and looking like shale. In the lower part of this stratum, there is intercalated a layer of conglomerate consisting of pebbles of a light grey Fusulina-limestone and of red and green tuffites, cemented by a green tufaceous matter, while in its upper part we find a stratum

of limestone-breccia between, the limestone being similar to that of the conglomerate. The whole bed is pierced here and there by dykes of porphyrites and quartz-porphyries, often causing contact metamorphism.

The whole complex of strata from No. 1 to No. 3 rests on a Palæozoic formation whose upper part at least is attributable to the Carboniferous.

The *Pseudomonotis* bed (No. 1) in Japan is now generally accepted as an equivalent of the Noric stage of the Alpine Keuper. Therefore I once thought that the plant-bed which is immediately above it at Nariwa might belong also to the same stage; but a closer examination of the fossil plants, though fragmentary and not clearly determinable, gives one the impression that they belong to a somewhat higher horizon. The species of plants which I have been able to distinguish in them are as follows:

1. **CLADOPHLEBIS** SP.

Pl. III. Fig. 2, 4, 7.

Fragments of the pinnæ of a *Cladophlebis* with pinnules which show a close resemblance to those of *C. nebbensis* (BRGNT.), occurring in the Rhætic of Nagato. The fine lateral veins of the pinnules are not always clearly observable, but when distinct, they are forked only once.

2. **SAGENOPTERIS** SP.

Pl. III. Fig. 3.

A segment of a *Sagenopteris* lacking the apex. It has an elongated shape, broadest near the middle and tapering toward

both ends, being cuneate at base. The broadest part measures 21 mm; the length may be estimated at about 55 mm. The midrib is rather weak, becoming very weak towards the apex. The lateral veins are very fine, rise at acute angles from the midrib and are divergent, although anastomosing with one another to form elongated nets.

That this fragment belongs to the above named genus can hardly be doubted. It is very likely that it represents a form which, if not quite identical with, is at least closely akin to, *Sagenopteris Phillipsi* PRESL (MÖLLER, *Bidrag till Bornholms Fossila Flora, Pteridofyter, pl. V, fig. 1-7*) and *S. rhoifolia* PRESL (SCHENK, *Die Fossile Flora der Grenzsichten des Keupers and Lias Frankens, pl. XII*), both from the Rhætic of Europe.

3. **ARTHROPHYOPSIS** ? sp.

Pl. III. Fig. 6.

A small fragment of a fern-frond (?), having distinct, equal, and more or less parallel veins which here and there unite to form long nets. According to this mode of venation, it bears a close resemblance to what Nathorst has given the name of *Arthrophyopsis Nilssoni* (*Floran vid Bjuf, pl. VII, fig. 5, VIII, 6. Floran vid Höganäs und Helsingborg, pl. I. fig. 6*) from the Rhætic of Sweden.

4. **NILSSONIA** sp.

Pl. III. Fig. 1, 8.

There are two specimens of a *Nilssonia*, which, though somewhat different in appearance, probably belong to the same

species. Fig. 1 shows the back-side of a leaf while fig. 8 shows the upper or front side of the same. The midrib, though not very strong, is rigid with lateral veins, either at nearly right angles to it, or slightly inclined forward. The leaf seems to have been either entire or only partly segmented.

The already known form of *Nilssonia* which can be compared to the present one is *Nilssonia polymorpha* SCHENK (Nathorst, *Beitr. z. foss. Flora Schwedens, pl. XI*) from the Rhætic of Europe.

5. **PODOZAMITES LANCEOLATUS** (LINDL. ET HUTT.)

Pl. III. Fig. 5.

A leaf lacking the apical portion. The general outline and fine parallel longitudinal veins, numbering about 25, show that it belongs to the above named species of *Podozamites*, widely distributed in the Rhætic as well as in the Jurassic.

Although the above five plants are by no means decisive in determining the age of the bed in which they occur, yet their general character indicates that they belong most likely to the Rhætic. This is supported, not only by the occurrence of anthracite layers as in the Rhætic of Nagato, but also by the presence of a schalstein above, a rock which exhibits a great similarity to the so-called *Inkstone* (schalstein) of the *Inkstone Series* of the latter place. And as the lower part of this series has already been proved to be Liassic, the schalstein of Nariwa, if not entirely, at least its lower part may also be looked upon as belonging to the same age.



M. YOKOYAMA.

MESOZOIC PLANTS FROM NAGATO AND BITCHU.

PLATE I.

Plate I.

(Plants from Nagato).

Figs. 1, 2, 3. *Cladophlebis nebbensis* (BRGNT.).

Fig. 4. *Nilssonia Inouyei* YOK.

Figs. 5, 7. *Dictyophyllum Kochibei* YOK.

Fig. 6. *Podozamites lanceolatus* (LINDL.).



Fig. 1.



Fig. 5.



Fig. 4.



Fig. 2



Fig. 6.



Fig. 3.

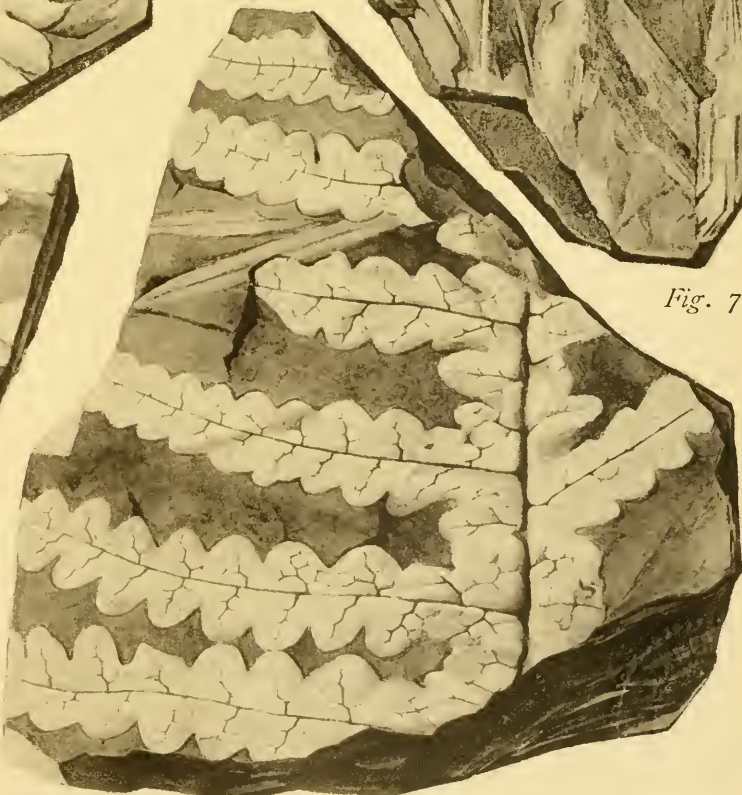


Fig. 7.

YOKOYAMA.

MESOZOIC PLANTS FROM NAGATO AND BITCHU.

PLATE II.

Plate II.

(Plants from Nagato).

- Fig. 1. *Dictyophyllum Kochibei* YOK.
- Fig. 2. *do. Fertile pinna.*
- Fig. 3. *Dictyophyllum japonicum* YOK.
- Fig. 4. *Nilssonia Inouyei* YOK.
- Fig. 5. *Baiera paucipartita* NATH.



Fig. 1.



Fig. 4.



Fig. 2.

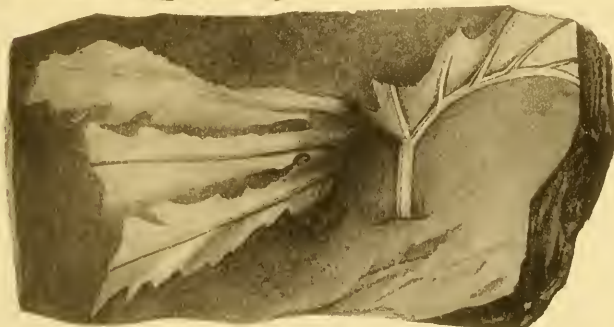


Fig. 3.



Fig. 5.

Plate III.

(Plants from Bitchu).

Figs. 1, 8. *Nilssonia* sp.

Figs. 2, 4, 7. *Cladophlebis* sp.

Fig. 3. *Sagenopteris* sp.

Fig. 5. *Podozamites lanceolatus* (LINDL.).

Fig. 6. *Arthrophyopsis* ? sp.

Fig. 1.



Fig. 6.



Fig. 4.



Fig. 2.



Fig. 7.

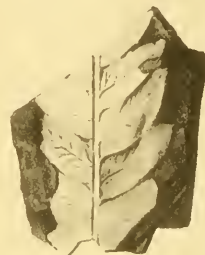


Fig. 5.



Fig. 3.

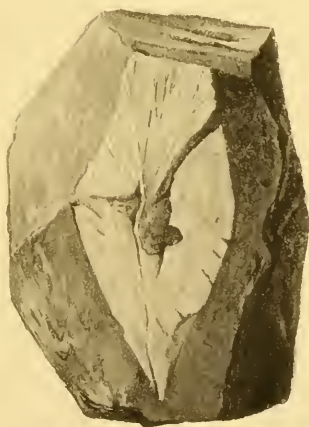


Fig. 8.



On the Magnetization and the Magnetic Change
of Length in Ferromagnetic Metals and
Alloys at Temperatures ranging
from -186°C to $+1200^{\circ}\text{C}$.

By

K. Honda, *Rigakuhakushi*.

and

S. Shimizu, *Rigakushi*.

With 4 plates.

In this journal Vol. XIX., Art. 11, 1903, Professor H. NAGAOKA and one of us published the result of experiments on the magnetization and magnetostriction of nickel steels containing different percentages of nickel. The present experiment was undertaken, on the one hand, to extend the above investigation to different temperatures, and on the other hand, to form a continuation of our former experiment.*

The experiment was made in three separate stages. In the first experiment, which extended from February 21 to July 2, 1903, the magnetization and the magnetic change of length at ordinary and liquid air temperatures were measured; in the second experiment extending from January 17 to February 2,

*) K. HONDA and S. SHIMIZU, this Jour. Vol. XIX, Art. 10, 1903.

1904, the same measurements were extended so as to include different intermediate temperatures between the ordinary and liquid air temperatures; lastly in the third experiment, which extended from March 10 to May 17, 1904, the magnetizations at high temperatures were measured.

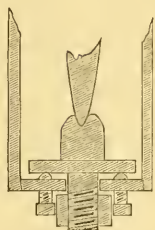
Our specimens consisted of five ferromagnetic metals, and twelve specimens of nickel steels, kindly placed at our disposal by M. Ch. Ed. GUILLAUME. They were all examined in the form of ovoids (major axis=20 cm and minor axis=1 cm).

In the first experiment, the specimens were first annealed for about 4 hours at 1000°C – 1100°C in charcoal fire, after they were well wrapped in asbestos, and then gradually cooled. These annealed specimens were tested at the ordinary, then at liquid air temperature, and lastly again at ordinary temperature. In the second experiment, the measurement was always commenced with freshly annealed ovoids. Lastly in the third experiment, all specimens were cooled in liquid air for about 15 or 20 minutes. The measurements at the ordinary, and then at higher temperatures, were carried out; the measurements at different descending temperatures down to the ordinary were also made. Thus all the measurements, when set down in order, form a complete cycle with regard to temperatures, whose limits lie between liquid air temperature and 1200°C . The methods and the results of the experiments are given in the following pages.

I. FIRST EXPERIMENT.

The apparatus for measuring the change of length was similar to that used in our former experiment above referred to. The ends of the ovoid to be tested were soldered to two short brass

rods, each end of the ovoids entering about 2 mm into the rod.



The upper piece is connected with a wire stretched vertically, and the lower piece is screwed to the bottom of the specimen-holder, as shown in the annexed cut. The axis of the ovoid can be adjusted by three small screws. The holder was made of a copper tube, with three long slits, equally distant from one another, along its axis. These slits permit the

adjustment of the specimens to the axial line of the tube. The rest of our apparatus was exactly the same as in the former experiment.

In the present experiment, the magnetization was, at the same time, measured by the magnetometric method. The magnetometer consisted of a bell-shaped magnet suspended by a quartz fibre in a thick copper case. A magnetizing coil (length = 40 cm, $4\pi n = 394.4$) and a compensating coil of nearly the same dimensions were placed respectively due magnetic east and west of the magnetometer. The magnetometer was placed in such a position that the specimen exerted the maximum effect upon it. The vertical component of the earth's field was compensated for. The deflection of the magnetometer was measured by means of a scale and telescope.

In measuring magnetization, the following precautions were taken. The verticality of the two coils was tested by means of a level. The line of the magnetometer, the compensating coil and the magnetizing coil, was then tested by a compass needle. The compensation of the earth field and then that of the magnetizing coil were next effected; lastly the scale and telescope were placed in correct positions.

The precautions above enumerated were especially necessary, as the magnetization and the magnetic hysteresis in strong fields

were to be studied with the ovoids placed in vertical positions. Though these precautions were taken with the utmost care, the magnetizations by opposite currents of equal strength were not exactly equal in absolute amounts, so that a small asymmetry of the hysteresis curve was also observed in the strong fields. This difference was, in the most unfavorable case, not greater than 1% of the total magnetization for a field of 700 C.G.S. This probably arose from a slight deviation of the coils from the vertical line. If the lines of force at the center of the magnetometer be not vertical, but be in the meridian plane, the field due to the coils may slightly affect the horizontal component of the earth's field, without producing any deflection of the magnetometer. If the horizontal component be increased by a current in one direction, a current in the opposite direction will diminish it. In the first experiment, therefore, two magnetizing curves for opposite currents were taken. These two curves almost coincided with each other below a field of 200 C.G.S., but slightly deviated above that field. Since the disturbing force is proportional to the magnetizing current, the correction for the intensity of magnetization can be derived from a pair of the opposite magnetizations by equal and opposite currents; hence in the second and third experiments, the magnetizations by equal and opposite currents of the maximum strength were taken, and the correction was found, and applied to magnetization by currents of one direction.

The current was measured by a SIEMEN-HALSKE ammeter, which was occasionally compared with a KELVIN ampere-balance.

The experiment was conducted in the following order. The adjustment of the magnetizing and compensating coils having been completed, the specimen-holder containing the ovoid was fixed vertically in the correct position in the magnetizing coil. The ovoid

was then vertically stretched upwards by means of a copper wire with a spiral spring, special care being taken to stretch the copper wire in the direction of the axis of the ovoid. The magnetic change of length was then measured in the usual way. The magnetization and the magnetic hysteresis were next observed. Liquid air was next gently poured into the DEWAR tube in the magnetizing coil, until the tube was nearly filled with the liquid; then the exposed parts above the magnetizing coil were carefully protected with cotton wool. Owing to the boiling of the liquid, a small oscillation of the image in the field of the telescope was at first observed; but after some ten minutes, the image became almost steady. The change of length was then taken. Next, adding more liquid air to that in the DEWAR tube, when necessary, the magnetization and the magnetic hysteresis were measured. Lastly when the specimen was heated to the temperature of the room, the change of length and the magnetization were again noted. After the experiments, the compensation of the magnetizing current was always tested, and found perfect, except in a few cases.

(a) Magnetization of Ferromagnetic Metals.

In Table I, the magnetization in different fields is given, where I is the intensity of magnetization, and H the internal field (external field—demagnetizing force). The temperature of liquid air has been assumed to be -186°C ; but owing to the fractional evaporation of nitrogen, as the experiment proceeds, the actual temperature may, according to circumstances, be greater or less by few degrees than the above value. The figures of the last row in each column are the residual magnetism, when the external field vanishes.

TABLE I.
SWEDISH IRON.

$t=27.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=21.5^{\circ}\text{C}$	
H	I	H	I	H	I
1.77	81	2.23	77	1.76	86
3.55	243	3.39	247	2.85	250
4.10	582	4.55	453	3.39	431
7.40	890	5.00	578	4.41	632
16.3	1138	15.4	1085	7.00	858
30.3	1251	44.7	1302	14.1	1102
53.4	1330	135.0	1464	33.7	1264
103.7	1419	221.8	1543	108.8	1424
234.6	1545	283.9	1587	225.4	1536
349	1609	385	1636	390	1623
473	1647	478	1665	485	1648
554	1621	543	1681	547	1660
	33.5		39.7		37.6

TUNGSTEN STEEL.

$t=23.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=30.7^{\circ}\text{C}$	
H	I	H	I	H	I
2.22	22	1.37	13	2.16	21
8.36	119	5.89	64	4.38	49
10.90	275	19.75	130	6.91	104
12.10	528	12.40	254	9.25	193
15.7	695	16.8	661	10.35	376
20.1	928	28.8	1035	25.8	1064
28.5	1062	62.7	1235	111.2	1326
96.6	1292	140.1	1371	216.2	1413
185.1	1381	272.4	1468	333	1463
282.1	1432	402	1523	397	1483
416	1477	469	1535	483	1499
574	1503	570	1557	557	1509
	123		136		127

NICKEL.

$t=13.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=17.0^{\circ}\text{C}$	
H	I	H	I	H	I
1.11	14	1.42	9	0.53	7
3.26	88	3.34	26	3.63	91
6.96	177	11.35	187	7.92	192
11.12	237	21.95	298	18.60	309
19.85	322	34.1	357	38.1	400
37.94	394	80.4	418	63.8	439
64.1	438	152.8	443	117.3	469
153.6	478	240.3	462	182.5	483
247.6	490	342	477	332	494
359	496	493	490	484	503
493	503	586	506	639	505
710	510	704	518	703	506

CAST COBALT.

$t=20.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=19.5^{\circ}\text{C}$	
H	I	H	I	H	I
5.1	72	3.90	28	2.58	22
10.7	170	10.57	122	14.14	223
13.9	247	22.65	277	20.03	302
22.8	371	39.3	427	24.85	374
35.7	497	74.7	608	33.1	454
54.5	628	101.9	690	50.6	594
85.9	749	206.6	848	77.3	676
147.7	865	281.1	911	121.3	780
244.3	953	357	956	275.3	941
392	1027	449	999	406	1010
467	1047	570	1038	543	1053
610	1088	668	1063	659	1083

ANNEALED COBALT.

$t=18.6^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=31.0^{\circ}\text{C}$	
H	I	H	I	H	I
4.37	6	7.80	9	6.94	8
13.53	26	16.23	20	18.39	29
25.25	67	39.0	64	29.23	56
36.59	115	57.8	102	45.07	108
52.5	171	80.0	148	65.0	164
86.7	257	119.6	221	95.7	232
122.3	320	167.4	282	147.5	313
221.8	433	248.4	358	167.3	415
354	532	347	426	364	508
445	583	496	504	484	572
527	613	561	543	542	603
699	687	702	589	684	664

From these numbers, we see that in Swedish iron, tungsten steel and nickel, the cooling by liquid air diminishes the magnetization in low fields, but increases it in the strong. In Swedish iron and tungsten steel, the change is very small, amounting at most to 2 or 3 per cent; but in nickel, the initial diminution is considerably larger, amounting to about 10 per cent in the maximum. The field, in which the effect of cooling changes its sign, is 115 C.G.S. for Swedish iron and tungsten steel, and 580 C.G.S. for nickel. FLEMING and DEWAR* who first thoroughly studied the magnetization of iron and steel in liquid air, did not observe an increase of magnetization; perhaps the field was too weak to indicate such an increase.

In cast and annealed cobalts, cooling always diminishes magnetization; the effect is rather greater in cobalt when annealed than in the cast state.

*) FLEMING and DEWAR, *Proc. Roy. Soc.*, **60**, 81, 1896.

In Swedish iron, tungsten steel and nickel, the magnetizations before and after the cooling coincide with each other for all fields. In cast and annealed cobalts, there is a considerable residual change of the magnetic condition.

(b) **Magnetization of Nickel Steels.**

The intensities of magnetization at the temperatures of the room and of liquid air are given in Table II.

TABLE II.

NICKEL STEEL 70.32%.

$t=21.1^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=30.5^{\circ}\text{C}$	
H	I	H	I	H	I
0.24	9	0.28	6	0.93	35
1.52	120	2.02	96	1.52	127
2.20	310	2.61	221	1.65	233
3.91	500	3.62	455	2.75	374
11.20	721	10.94	662	6.07	593
17.20	794	20.5	835	11.17	712
32.5	903	31.4	911	16.20	784
63.3	969	45.5	971	36.9	869
91.4	988	81.4	1031	52.9	952
232.1	1004	169.3	1063	101.3	987
381	1008	253.3	1072	186.0	996
492	1008	337	1078	283.6	999
576	1008	439	1088	438	999
672	1009	601	1098	628	999
	22.2				

NICKEL STEEL 50.72%.

$t = 24.0^{\circ}\text{C}$		$t = -186^{\circ}\text{C}$		$t = 32.0^{\circ}\text{C}$	
H	I	H	I	H	I
1.86	58	1.22	33	1.54	55
2.92	207	3.80	197	2.24	112
3.35	324	4.13	333	2.74	191
5.16	569	5.55	509	4.44	498
8.80	727	8.27	712	8.77	736
17.12	946	21.9	1003	19.52	961
36.4	1076	27.2	1051	33.4	1066
51.4	1137	41.6	1133	49.5	1126
73.0	1181	65.8	1207	84.8	1184
146.3	1225	148.0	1285	168.0	1220
251.4	1241	230.6	1302	255.3	1229
328	1244	315	1308	375	1230
426	1246	439	1310	518	1235
604	1247	573	1312	602	1237

NICKEL STEEL 46%.

$t = 20.0^{\circ}\text{C}$		$t = -186^{\circ}\text{C}$		$t = 21.0^{\circ}\text{C}$	
H	I	H	I	H	I
0.29	7	1.59	38	1.54	47
2.30	79	6.00	359	2.79	116
3.02	175	7.90	554	3.74	228
4.08	279	10.85	770	5.55	490
4.92	362	19.90	974	10.49	754
5.88	473	26.60	1059	15.30	883
8.22	684	39.6	1147	29.8	1029
11.10	793	49.0	1187	66.5	1145
17.15	909	72.8	1246	166.4	1206
33.8	1054	100.9	1295	311	1219
91.1	1171	166.6	1338	411	1221
266.7	1214	242.5	1360	489	1222
372.1	1219	455	1377	608	1222
532.9	1222	631	1384		

NICKEL STEEL 36%.

$t=13.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=19.0^{\circ}\text{C}$	
H	I	H	I	H	I
1.27	32	2.18	30	1.48	36
2.45	73	6.00	207	3.39	138
4.00	176	8.16	426	5.37	335
7.45	472	11.70	621	9.14	550
9.50	524	16.60	801	12.60	658
11.55	624	26.3	982	16.95	741
16.05	714	52.2	1153	29.4	863
30.4	853	72.8	1210	55.9	939
65.1	953	121.5	1279	102.2	985
110.5	989	169.0	1310	187.4	1002
203.5	1007	248.3	1332	341	1014
350	1012	326	1344	436	1015
473	1013	450	1354	528	1016
662	1014	636	1367	657	1017

NICKEL STEEL 29.24%.

$t=23.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=36.5^{\circ}\text{C}$	
H	I	H	I	H	I
1.58	41	5.32	33	0.69	5
2.46	66	12.97	146	4.00	27
4.41	92	24.48	382	8.45	63
22.40	138	29.38	464	18.14	180
28.5	144	43.2	573	26.45	316
35.3	147	59.0	658	38.4	394
43.7	150	71.0	696	54.1	414
83.6	156	101.1	793	91.5	544
210.5	171	152.4	886	117.8	592
324	181	235.0	981	210.4	677
440	189	307.4	1030	320	740
504	193	403.1	1080	465	789
592	197	519	1121	551	808
657	201	591	1135	623	887
			192		171

NICKEL STEEL 29%.

$t=12.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=16.0^{\circ}\text{C}$	
H	I	H	I	H	I
1.00	11	2.24	9	2.20	8
2.95	131	10.13	93	4.52	29
7.60	207	13.39	155	9.35	75
19.6	272	20.74	321	12.92	123
67.1	307	29.5	505	15.95	180
143.7	315	37.6	608	24.72	355
243.6	321	48.0	708	44.2	582
400	328	75.0	858	74.5	708
515	333	139.6	1036	105.7	779
532	333	182.9	1104	174.9	874
738	341	356	1247	279.3	954
		424	1276	378	1004
		517	1306	547	1052
		631	1330	664	1079

NICKEL STEEL 28.74%.

$t=22.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=26.0^{\circ}\text{C}$	
H	I	H	I	H	I
0.29	6	2.97	14	0.85	4
1.61	70	6.85	35	8.91	77
4.20	156	11.42	106	13.12	128
13.70	242	18.28	201	17.01	193
29.20	278	27.82	378	22.38	325
46.2	292	30.8	427	33.0	453
87.0	305	39.5	549	48.1	566
159.3	314	66.7	730	79.6	658
233.3	319	178.9	991	111.8	746
320	321	235.3	1060	207.7	851
406	327	316	1098	307	911
472	328	375	1153	457	966
627	333	461	1191	543	987
672	335	523	1227	662	1110
	17.3		226		182

NICKEL STEEL 28.32%.

$t=17.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=31.7^{\circ}\text{C}$	
H	I	H	I	H	I
0.52	6	3.06	23	3.77	24
2.42	23	5.21	54	6.56	51
6.40	37	9.54	107	12.34	134
14.58	48	12.43	156	21.09	262
24.24	53	23.45	375	28.10	342
43.1	59	42.7	558	44.0	452
97.2	69	86.0	759	96.0	609
206.0	84	128.8	866	188.4	726
327	98	175.9	944	264.6	799
493	112	253.4	1029	438	886
596	119	360	1104	504	904
672	126	429	1132	602	931
752	128	515	1161		
		578	1178		
	0		145		141

NICKEL STEEL 26.64%.

$t=22.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=27.7^{\circ}\text{C}$	
H	I	H	I	H	I
23.2	2	3.57	18	3.87	2
71.6	5	8.72	45	9.03	49
124.3	8	13.90	105	16.47	129
225.0	11	18.10	194	23.89	267
355	14	28.15	369	38.7	488
524	17	48.5	605	50.5	613
635	18	57.2	671	65.2	721
744	20	73.9	764	89.2	836
		107.6	893	145.7	982
		169.8	1023	230.0	1085
		246.0	1118	307.2	1161
		383	1219	422	1231
		466	1260	501	1255
		559	1293	621	1287

NICKEL STEEL 25%.

$t=12.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=15.0^{\circ}\text{C}$	
H	I	H	I	H	I
—	—	32.9	1.1	—	—
—	—	53.1	2.3	58.3	0.6
—	—	91.8	3.7	94.9	1.4
—	—	128.1	5.4	155.8	2.3
354	0.4	209.5	8.0	344.8	2.9
—	—	313	11.0	401	3.2
516	2.0	498	15.2	529	3.3
		605	17.5	749	3.3
		752	20.3		

NICKEL STEEL 24.40%.

$t=18.7^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=23.5^{\circ}\text{C}$	
H	I	H	I	H	I
29.5	1.9	6.22	23	1.03	3
71.0	3.4	12.54	60	12.22	78
126.2	5.4	28.15	241	19.16	153
230.4	7.8	40.4	359	26.2	260
412	9.3	62.7	529	37.1	408
541	10.6	93.6	675	47.6	508
653	10.8	120.0	747	63.1	630
769	11.5	183.5	860	83.7	731
		238.1	926	119.6	839
		282.8	989	174.7	933
		370.4	1034	272.8	1024
		448	1067	438	1141
		510	1107	530	1174
		575	1137	644	1210
	2.0		251		232

NICKEL STEEL 24.04%.

$t = 16.0^{\circ}\text{C}$		$t = -186^{\circ}\text{C}$		$t = 30.0^{\circ}\text{C}$	
H	I	H	I	H	I
9.5	2.6	0.99	3	3.32	11
19.6	7.2	4.35	14	8.28	36
33.8	14.1	11.14	44	16.58	101
52.8	22.2	27.35	191	29.8	295
89.8	33.2	32.9	262	54.4	575
141.3	42.4	61.3	526	67.6	657
226.6	53.1	83.4	643	83.9	741
417	68.4	107.0	725	124.3	861
536	75.6	183.8	870	169.5	942
626	79.9	260.6	968	222.8	1012
763	85.4	376	1053	322	1090
		466	1101	418	1155
		540	1143	512	1191
		591	1152	579	1212
	9.3		280		256

As in the case of iron, tungsten steel and nickel, the magnetization of the alloys of nickel steels containing percentages of nickel greater than 26.64% is decreased in weak fields and increased in strong, by cooling them in liquid air. In alloys containing lower percentages of nickel, the magnetization always increases on cooling. The amount of the change of magnetization by cooling is considerably large; with the exception of 28.73% nickel steel, it increases as the percentage of nickel decreases, up to 26.64%. The magnetization in liquid air of 25% nickel steel, which is almost non-magnetic at ordinary temperatures, is also very small. As the percentage of nickel further decreases, the change of magnetization by cooling again increases. With 26.64% nickel steel, which undergoes the greatest change of magnetization

in liquid air, the intensity of magnetization increases from 16 to 1275 for $H=600$ C.G.S., or by about 80 times.

The magnetizations, before and after cooling, of reversible nickel steels containing greater percentages of nickel than 36%, nearly coincide with each other. If, however, irreversible nickel steels be once cooled in liquid air, the recovery to the initial value becomes less and less, as the percentage diminishes; in 24.40% and 24.04% nickel steels, the magnetization after cooling is even greater than that in liquid air. Some of the above results had already been obtained by HOPKINSON*, OSMOND†, and DUMAS‡.

(c) Hysteresis-loss in Ferromagnetic Substances.

The hysteresis was studied at the temperature of the room and at that of liquid air. The areas of the hysteresis-loops were carefully measured by a planimeter with the results given in Table III. and in Fig. 1 a, b.

TABLE III.

FERROMAGNETIC METALS.

	Ordinary temperature.				Liquid air temperature.			
Swedish iron.	H	4.0	6.0	15.8	H	1.9	6.4	63.7
	B	4504	10660	17160	B	4792	10680	17400
	W	2236	8195	20960	W	2091	8518	23070
Tungsten steel.	H	10.7	16.8	91.5	H	12.5	18.3	91.5
	B	3493	10030	16460	B	3223	9668	16520
	W	4610	25790	56520	W	4266	28320	69750

*) HOPKINSON's original papers, Vol. II, p. 227.

†) OSMOND, C.R. CXXVIII, p. 306 and 1396, 1899; C.R. CXVIII, p. 532, 1894.

‡) DUMAS' Recherches sur les Aciers au Nickel, p. 49—67, 1902.

	Ordinary temperature.				Liquid air temperature.			
Nickel.	H	6.3	20.9	120.5	H	1.1	26.8	122.2
	B	1996	4405	5931	B	1569	4117	5518
	W	806	3341	3915	W	1589	6763	10240
Cast cobalt.	H	6.6	12.6	92.4	H	7.4	14.8	96.3
	B	1107	2753	9259	B	960	2425	8676
	W	481	2391	21220	W	441	2272	21880
Annealed cobalt.	H	43.7	117.2	2180	H	48.3	122.7	224.3
	B	1802	3702	5508	B	1115	2893	4466
	W	5669	22680	35770	W	3244	19970	38710

Here H, B and W denote respectively the internal field, the magnetic induction, and the hysteresis-loss, all expressed in C.G.S. units. In Swedish iron, the hysteresis-loss is decreased in weak inductions and increased in the strong, by cooling it in liquid air. FLEMING and DEWAR* found no effect of cooling on the hysteresis-loss of iron. In tungsten steel, nickel, cast and annealed cobalts, the hysteresis-loss is always increased by cooling. These changes are briefly expressed by saying that the cooling in liquid air magnetically hardens the specimens.

In comparing the hysteresis-loss of different metals, it is to be observed that the hysteresis-loss in nickel is the smallest among them and that those for tungsten steel and cast cobalt are greater by about three times than the hysteresis-loss of Swedish iron, and the same relation also holds between annealed cobalt and tungsten steel.

From the courses of the curves in Fig. 1, it is evident that Steinmetz's formula giving the relation between the hysteresis-loss and the maximum induction holds for nickel and annealed cobalt up to an induction of 3000 C.G.S.; it holds for cast cobalt and

*) FLEMING and DEWAR, loc. cit.

tungsten steel up to 8000 C.G.S.; and lastly for Swedish iron, it fails beyond an induction of 18000 C.G.S. If, however, the specimens are cooled in liquid air, the applicable range of the law for induction is notably extended, as may be seen from Fig. 1.

As regards the residual magnetism, the cooling always increases it in a marked degree.

(d) **Hysteresis-loss in Nickel Steels.**

The hysteresis of nickel steels was studied at ordinary temperature, and seven of them at liquid air temperature. The results are given in Table IV and in Fig. 2 a, b.

TABLE IV.

NICKEL STEELS.

	Ordinary temperature.			Liquid air temperature.				
70.32%	H	2.1	3.4	31.2	H	2.5	4.9	30.2
	B	2675	7069	11370	B	2628	6850	11550
	W	886	3510	5353	W	9841	4140	7494
50.72%	H	3.9	4.6	38.9				
	B	4104	6790	13910				
	W	2015	4300	11160				
46%	H	2.9	4.9	7.0	H	2.6	4.9	6.8
	B	1350	3845	7783	B	919	3493	7677
	W	202	1969	5836	W	1026	1970	6867
36%	H	4.0	9.5	39.7	H	5.8	9.5	31.0
	B	2782	6910	11520	B	2581	6948	12800
	W	1264	5290	9404	W	1654	8000	19303
29.24%	H	0.7	6.9	78.0				
	B	749	2774	419				
	W	14.7	109	155				

	Ordinary temperature.				Liquid air temperature.			
29%	H	1.3	9.7	33.7	H	5.0	14.5	22.6
	B	1099	2807	3654	B	507	2132	5188
	W	106	395	393	W	79	2271	13120
28.74%	H	0.89	4.96	53.3				
	B	1261	3054	4662				
	W	58	189	322				
28.32%	H	46.5	218.6	—	H	11.8	19.3	57.2
	B	673	1184	—	B	1938	3964	8394
	W	4.5	16	—	W	1888	7439	28060
26.64%	H	25.3	62.3	148.7	H	14.5	23.2	60.2
	B	64	173	354	B	1552	3406	8076
	W	51	276	703	W	1396	7864	36900
24.40%	H	35.6	85.0	126				
	B	94	215	295				
	W	153	511	731				
24.04%	H	30.3	102.7	241.6	H	17.1	29.6	89.4
	B	331	608	926	B	1180	3212	8783
	W	1110	2586	4108	W	1309	10520	63550

The hysteresis-loss of nickel steels at ordinary temperature is generally small compared with other ferromagnetic metals. The values for reversible alloys are, however, comparable with those of nickel; but for irreversible alloys, they are all very small. Especially nickel steel of 28.32% does not almost enclose any area, giving only 16 ergs for an induction of 1200 C.G.S. If the alloy has a greater value for induction, it will be very useful for the construction of transformers. Thus the magnetic state of the irreversible nickel steels corresponds to that of ferromagnetic metals at high temperatures. As seen from Fig. 2 a, the Steinmetz's formula does not apply, except for very weak inductions.

If the alloys be cooled in liquid air, the hysteresis-loss increases. With irreversible alloys, the increase is enormous.

The applicable limit of Steinmetz's formula becomes greatly extended. Thus we may say, as in the case of the pure metals, that the cooling in liquid air hardens the specimens magnetically.

As regards the residual magnetism, the cooling considerably increases it.

(e) **Length Change of Ferromagnetic Metals.**

Table V and Fig. 3 a, b give the observed changes of length at the temperatures of room and of liquid air. Here $\frac{\delta l}{l}$ denotes the elongation per unit of length.

TABLE V.
SWEDISH IRON.

$t=24.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=29.0^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
4.0	0.21	3.0	0.9	4.0	0.7
8.5	2.7	5.3	1.5	5.1	1.6
21.7	3.5	20.0	3.2	11.7	3.4
72.4	3.3	66.5	3.2	37.0	4.2
123.5	2.4	165.0	0.9	104.0	3.3
217.5	0.13	274	-2.0	214	1.1
326	-2.3	396	-4.5	313	-0.8
483	-4.8	565	-7.6	478	-3.3
640	-6.2	—	—	642	-4.5
792	-7.0	814	-10.2	839	-5.1

TUNGSTEN STEEL.

$t=23.2^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=30.7^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
10.0	0.2	17.6	0.9	13.7	1.0
13.9	1.5	30.0	3.1	20.7	3.1
31.0	3.5	91.0	4.3	45.7	4.3
81.0	4.6	174	4.3	112.3	4.8
209	4.4	287	3.4	174.2	4.5
393	3.4	366	3.1	363	3.4
507	2.6	525	2.3	527	2.6
671	2.4	587	2.1	640	2.3
818	2.1	827	1.5	848	1.9

NICKEL.

$t=19.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=14.0^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
5.4	-2.3	3.6	-0.8	5.0	-1.5
10.0	-6.5	9.6	-2.5	7.6	-4.0
18.3	-12.1	16.0	-7.4	13.4	-8.8
32.2	-19.4	31.2	-15.9	29.2	-18.0
75.0	-29.5	74.9	-24.4	59.3	-26.4
145.8	-34.7	138.4	-28.5	110.4	-32.2
243.6	-36.7	252.6	-31.7	215.5	-36.0
353	-37.3	441	-34.9	387	-37.2
492	-37.7	662	-37.9	485	-37.4
796	-38.0	800	-39.4	772	-37.7

CAST COBALT.

$t=20^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=20.0^{\circ}\text{C}$	
H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10^6$
14.3	-1.1	9.4	-0.3	15.6	-1.1
33.2	-4.2	30.0	-3.3	33.5	-3.5
62.3	-7.5	64.2	-7.5	63.4	-6.4
106.5	-9.3	126.4	-10.2	124.3	-7.7
167.1	-9.3	234.7	-11.7	231.3	-7.1
217.7	-8.5	350	-10.9	449	-5.7
348	-6.1	465	-9.8	465	-3.8
498	-4.0	616	-8.7	616	-1.5
762	-0.2	749	-7.2	755	-0.1

ANNEALED COBALT.

$t=13.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=25.5^{\circ}\text{C}$	
H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10^6$
31	-0.1	95	-0.3	59	-0.2
46	-0.2	167	-1.1	98	-0.9
86	-1.0	312	-2.7	153	-1.7
142	-1.8	422	-3.4	268	-3.3
224	-2.8	512	-4.5	444	-6.1
347	-4.3	635	-6.1	538	-7.6
498	-6.1	755	-7.4	717	-10.3
647	-7.9	772	-7.6	869	-12.4
800	-9.8				

In Swedish iron and tungsten steel, cooling by liquid air decreases the elongation of the metals; the change in tungsten steel is very small, but in Swedish iron, it is relatively large. In nickel, the contraction is diminished by cooling to a field of 670 C.G.S.; but it is increased in stronger fields. In cast cobalt, the contraction is considerably increased, except in weak field, where a slight decrease of contraction is observed. In annealed cobalt, the contrary is the case; the contraction is always diminished.

With tungsten steel and nickel, the magnetic changes of length before and after the cooling coincide with each other. But in Swedish iron, the elongation after cooling becomes greater than that before cooling. In cast cobalt, the magnetic contraction after cooling slightly decreases, as compared with the elongation before cooling; but with annealed cobalt, the contrary is the case, except in weak field.

The above results for Swedish iron, nickel and annealed cobalt agree with those obtained by us* with rods of these metals. The change of elongation of tungsten steel in high fields does not coincide with that of our former experiment. But the change being very small, the discrepancy may be accounted for by taking into consideration the demagnetizing force, with which our former experiment was not concerned.

(f) Length Change of Nickel Steels.

The observed changes of length are given in Table VI and in Fig. 4 a, b, c, d, e, f, g, h, i.

*) K. HONDA and S. SHIMIZU, loc. cit.

TABLE VI.

NICKEL STEEL 70.32%.

$t = 22.0^{\circ}\text{C}$		$t = -186^{\circ}\text{C}$		$t = 26.5^{\circ}\text{C}$	
H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10^6$
3.0	0.6	3.0	0.7	2.9	0.9
8.3	3.2	19.0	5.2	20.2	5.3
21.1	6.1	32.8	8.6	67.9	10.4
45.9	9.2	85.3	11.1	121.2	11.6
109.4	11.2	106.8	12.1	280.1	11.9
232.6	11.7	228.7	12.8	422	12.0
392	11.8	334	12.9	499	12.0
546	11.9	473	13.0	639	11.9
663	11.7	631	12.9	802	11.9
791	11.6	763	12.6		

NICKEL STEEL 50.72%.

$t = 26.5^{\circ}\text{C}$		$t = -186^{\circ}\text{C}$		$t = 27.5^{\circ}\text{C}$	
H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10$
3.8	0.6	3.8	0.4	5.0	1.0
6.8	2.6	6.8	1.9	9.9	4.3
11.3	5.5	13.0	5.1	44.2	14.5
23.8	10.2	41.0	12.8	102.7	19.8
56.6	16.0	106.0	20.7	236.0	22.8
182.8	22.1	207.2	24.8	363	23.5
280.2	23.0	351	26.4	482	24.1
449	24.0	506	26.7	673	24.7
561	24.2	665	26.7	783	24.9
695	24.3	835	26.8		

NICKEL STEEL 46%.

$t=20.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=21.0^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
4.0	0.3	5.0	0.9	4.0	0.6
7.0	2.8	7.7	2.8	4.8	1.2
15.5	6.2	26.4	9.2	9.4	4.0
76.3	18.5	82.0	20.4	28.1	10.5
168.0	22.7	113.0	22.0	88.7	19.0
255.5	23.8	310	28.6	207.9	22.8
440	24.8	522	29.5	326	23.7
608	25.3	728	30.7	442	24.0
760	25.4			603	24.4
				746	24.4

NICKEL STEEL 36%.

$t=20.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=14.0^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
5.1	0.3	5.6	0.6	5.3	0.3
10.2	2.7	10.4	1.4	13.0	3.3
37.8	8.0	28.2	5.1	27.9	6.6
101.4	13.5	76.3	14.0	71.9	11.8
205.9	16.0	186.4	23.8	174.8	15.5
363	17.4	289.8	26.5	298	16.8
503	18.4	428	28.8	441	17.6
616	19.0	587	29.8	592	18.6
756	20.3	738	30.5	717	19.3

NICKEL STEEL 29.24%.

$t=19.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=23.6^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
16.0	0.6	18.5	0.3	20.0	0.3
55.0	1.0	26.0	0.9	52.6	1.7
93.3	1.7	66.8	2.7	101.9	3.2
149.8	3.4	142.2	6.0	171.8	4.9
291.8	3.6	264.0	9.6	304	7.7
441	5.3	422	13.1	444	9.8
591	6.7	524	15.0	565	11.5
699	7.8	675	16.5	708	13.1
897	9.7	837	17.8	801	13.9

NICKEL STEEL 29%.

$t=11.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=14.0^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
15.4	1.1	22.9	0.1	18.8	0.3
36.9	1.9	49.3	2.5	31.8	1.1
83.6	2.7	105.7	7.7	59.6	3.2
147.6	3.4	206.9	12.6	122.2	5.6
323	4.9	313	16.4	349	11.1
472	6.9	412	18.0	470	12.8
692	9.0	555	20.1	633	14.5
850	10.3	681	21.6	770	15.8

NICKEL STEEL 28.74%.

$t=22.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=21.5^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
11.4	0.6	35.0	1.0	16.0	0.2
46.7	1.7	81.0	4.0	37.0	1.6
92.6	2.4	138.7	6.7	76.0	3.5
155.7	2.7	184.7	8.2	133.2	5.6
281.0	4.2	248.0	10.3	250	8.5
419	5.6	327	11.8	337	10.3
681	7.2	519	15.4	457	12.4
782	8.6	687	17.7	633	14.7
		822	19.4	820	16.7

NICKEL STEEL 28.32%.

$t=20.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=21.5^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
21.3	0.2	27.0	0.8	15.0	0.2
50.2	0.6	39.0	1.5	41.5	1.5
85.3	0.8	66.2	2.7	92.0	3.0
169.0	1.2	101.0	4.4	144.4	4.9
281.6	2.0	231	9.4	275	8.3
378	3.0	368	12.9	420	11.2
455	3.6	454	14.3	599	14.0
601	4.8	618	16.2	788	16.4
810	6.1	826	18.3	878	17.4

NICKEL STEEL 26.64%.

$t=24.5^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=21.0^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
28.7	0	19.6	0.2	20.0	0.3
81.3	0	42.0	1.6	47.2	2.4
118.2	0	92.6	4.8	94.0	5.7
180.0	0.08	145.0	6.9	168	9.3
302	0.13	255	10.8	300	12.8
489	0.15	353	12.9	408	14.9
680	0.17	490	15.4	530	16.9
890	0.21	593	16.9	668	18.2
		774	17.7	778	18.8
		935	19.5		

NICKEL STEEL 24.40%.

$t=25.0^{\circ}\text{C}$		$t=-186^{\circ}\text{C}$		$t=20.5^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
—	—	22.7	0.1	19.0	0.3
—	—	50.8	1.4	32.0	0.9
—	—	91.0	3.1	78.2	3.4
118	0	156.5	5.2	149	6.8
236	0	295	9.3	240	9.5
367	0.02	405	11.2	362	12.2
494	0.08	544	13.1	484	14.6
705	0.10	640	13.9	621	16.3
886	0.11	839	16.9	795	18.4

NICKEL STEEL 24.04%.

$t = 21.0^{\circ}\text{C}$		$t = -186^{\circ}\text{C}$		$t = 23.0^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
22.9	0	34.3	0.7	35.3	1.0
76.5	0.1	65.7	2.5	66.7	2.9
196.6	0.2	124.0	5.9	112.0	5.4
281.7	0.3	238.5	9.9	253	10.0
429	0.35	334	13.3	398	12.7
600	0.6	468	17.8	508	14.4
808	0.7	622	21.6	695	15.9
		835	25.6	858	16.9

The effect of cooling on the magnetic elongation in nickel steels is exactly parallel to the same effect on magnetization. In nickel steels containing percentages of nickel greater than 28.74%, the elongation is diminished in weak fields and increased in the strong, by cooling them in liquid air; with other nickel steels, the initial decrease of elongation vanishes.

The ratio of the elongation in liquid air to that at ordinary temperature increases in strong fields, as the percentages of nickel decreases. In 36% Ni, it amounts to about 1.6 in $H=500$ C.G.S.; and in 28.32% Ni, to 3.7, and in 24.40% Ni to 160 for the same field.

For reversible nickel steels, the elongations after and before cooling coincide with each other. The elongation of other nickel

steels, once cooled in liquid air, is always greater than that before cooling. With 26.64% and 24.40% alloys, the elongation is even increased, by heating it to the ordinary temperature.

25% nickel steel does not sensibly elongate at ordinary temperature nor in liquid air.

(g) **Change of Density by Cooling.**

The density of the irreversible nickel steels at ordinary temperature suffered a permanent change, if they were once dipped in liquid air. This singular fact was first observed by HOPKINSON*. The following table contains the observed values of density:—

TABLE VII.

Alloys	28.32% Ni	26.64% Ni	24.40% Ni	24.04% Ni
Before cooling	8.15	8.16	8.13	8.06
After cooling	8.01	7.99	8.06	7.94

Thus the density is diminished, by cooling them in liquid air; M. Ch. Ed. GUILLAUME† specially investigated this point, by measuring the coefficient of thermal expansion at low temperatures. He found that the irreversible nickel steels expand on being cooled in solid carbon dioxide and again expand when heated to ordinary temperatures. Hence the effect of cooling is to doubly diminish the density of the alloys.

*) HOPKINSON's Original Papers Vol. II, p. 240.

†) GUILLAUME, Bulletin de la Société d'Encouragement, mars 1898, p. 273.

II. SECOND EXPERIMENT.

To obtain a constant low temperature lying between the ordinary and the liquid air temperatures, a method of slow cooling was applied. The specimen-holder in the former apparatus was water-tightly covered with a brass cylinder, and a suitable amount of liquid air was poured into the interspace between the cylinder and the DEWAR tube. The temperatures above -15°C were, however, obtained by dipping the specimen directly into a freezing mixture (snow and common salt) contained in the DEWAR tube. The experiment was commenced with the specimen in the annealed state, and the measurements at successively decreasing temperatures were made. During one set of observations, which usually required 7 or 8 minutes, the temperature was fairly constant and its change did not exceed one degree in the most unfavorable case. Since the cooling was very slow and the specimen was doubly enclosed in copper and brass tubes, the temperature of the specimen may be regarded as constant throughout its entire length.

The temperature of the specimen was measured by a thermoelectric couple of platinum and german silver. The wires were insulated with a thin caoutchouc tube. One of the junctions was brought in contact with the specimen at its middle, while the other was insulated with asbestos papers and inserted in a copper tube. This tube was dipped into the water bath, and its temperature was observed with a thermometer placed in the bath. The thermoelectric current was measured with a low resistance galvanometer. The calibration of the galvanometer was made by using a mercury thermometer and a petroleum-ether thermometer.

Since the character of the pure metals and the reversible nickel steels were not much altered by cooling them in liquid air, the measurements of the magnetization and the magnetic change of length at the intermediate temperatures were confined to only the irreversible nickel steels, that is, those, whose percentage-contents of nickel were less than 29.24% (excluding 25% Ni).

(a) **Magnetization of Nickel Steels.**

The observed values of the intensity of magnetization are given in Table VIII. Here H and I have the same meaning as before.

TABLE VIII.

NICKEL STEEL 29.24%.

$t = -1.9^{\circ}\text{C}$		$t = -32.5^{\circ}\text{C}$		$t = -62.5^{\circ}\text{C}$	
H	I	H	I	H	I
0.15	10	0.16	8	0.16	15
0.40	41	0.23	48	0.66	24
0.79	79	0.49	105	2.26	76
1.34	110	1.10	167	5.40	152
3.19	172	2.19	232	9.01	227
6.88	226	3.89	298	17.07	341
12.33	264	11.22	381	22.65	391
22.81	287	12.49	453	33.8	450
46.2	297	67.6	530	61.9	561
75.4	301	120.9	565	120.0	670
151.5	306	188.0	583	234.7	758
313	311	323	590	329	811
448	315	369	596	408	812

NICKEL STEEL 29%.

$t=12.4^{\circ}\text{C}$		$t=-37.5^{\circ}\text{C}$		$t=-121.8^{\circ}\text{C}$	
H	I	H	I	H	I
0.21	18	0.24	24	0.42	8
0.61	69	0.52	52	1.93	53
0.98	109	1.01	107	3.93	107
1.84	164	2.30	203	9.87	215
3.00	214	4.19	287	16.30	309
5.34	273	9.20	405	22.58	376
13.17	352	15.50	475	45.5	506
26.62	375	31.1	521	77.3	614
66.4	382	62.2	539	160.5	740
161.2	387	126.9	544	280.8	813
302	390	261.5	546	395	845
438	392	416	548		
	3.5		5		47

NICKEL STEEL 28.74%.

$t=-10.4^{\circ}\text{C}$		$t=-54.5^{\circ}\text{C}$		$t=-108.0^{\circ}\text{C}$	
H	I	H	I	H	I
0.22	16	0.25	13	1.24	12
0.43	42	0.63	62	4.29	64
0.95	95	1.83	153	9.05	153
2.09	154	2.95	205	14.64	261
3.69	210	5.17	275	21.40	359
9.68	317	10.99	382	29.83	424
19.82	383	25.02	481	49.2	536
32.0	402	69.9	542	66.9	607
64.8	415	189.0	550	131.2	741
189.0	419	325	550	218.0	827
298.8	420	420	551	310	874
445	423			380	904
	2.4		3.8		91

NICKEL STEEL 28.32%.

$t = -12.5^{\circ}\text{C}$		$t = -45.0^{\circ}\text{C}$		$t = -79.5^{\circ}\text{C}$	
H	I	H	I	H	I
0.31	24	0.16	18	0.45	16
0.86	55	0.50	62	0.96	40
2.63	101	1.41	121	2.79	86
4.73	128	3.33	186	6.24	142
14.98	159	7.00	252	10.98	203
32.9	170	15.46	301	17.85	266
75.3	180	28.78	315	30.2	336
180.6	193	73.4	321	63.2	417
332	205	168.9	325	90.0	451
450	211	345	327	191.4	502
		438	328	305	526
				419	542
	0.5		0.4		19.5

NICKEL STEEL 26.64%.

$t = -9.6^{\circ}\text{C}$		$t = -36.5^{\circ}\text{C}$		$t = -80.0^{\circ}\text{C}$	
H	I	H	I	H	I
10.0	2.8	3.95	9	2.15	12
20.2	7.0	11.38	24	5.96	39
39.3	17.2	24.95	58	11.60	92
94.6	32.3	36.6	82	16.43	142
195.7	47.8	55.9	122	31.0	290
312	60.0	129.8	168	50.1	386
470	71.9	222.0	212	63.0	437
		332	247	97.2	524
		446	275	169.5	623
				224.6	726
				321	736
				392	770
	15.3		64		166

NICKEL STEEL 24.40%.

$t=6.5^{\circ}\text{C}$		$t=-13.9^{\circ}\text{C}$		$t=-68.7^{\circ}\text{C}$		$t=-105.5^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
11.4	1.9	5.1	2.1	3.0	7	2.6	9
16.9	3.2	11.5	6.1	10.4	28	9.2	38
27.2	5.4	19.1	13.0	16.8	57	18.5	108
38.5	7.7	28.2	21.2	26.0	119	25.1	176
55.9	11.1	43.2	33.5	35.8	187	32.1	268
98.9	16.1	64.5	43.7	57.3	283	45.6	339
193.9	24.5	102.7	58.4	69.6	335	75.7	481
291.4	31.5	170.4	75.8	104.9	401	106.8	561
391	37.2	255.5	90.5	177.0	488	166.2	651
		323	99.2	297.9	569	226.4	717
				407	618	320	786
						396	826
	7.3		33.6		192		226

NICKEL STEEL 24.04%.

$t=-6.2^{\circ}\text{C}$		$t=-13.2^{\circ}\text{C}$		$t=-60.8^{\circ}\text{C}$		$t=-99.0^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
5.9	3.2	4.4	4	4.1	9	2.6	8
13.1	9.4	11.6	11	11.2	32	7.3	24
26.2	26.0	25.2	37	20.6	82	16.1	66
43.7	46.8	40.5	71	34.1	191	21.4	123
74.1	72.8	79.4	123	49.1	285	29.3	223
134.1	95.3	159.5	175	66.2	363	49.2	367
228.8	118.8	295.4	219	101.1	461	62.8	452
342	137.3	393	239	184.8	580	80.4	533
457	148.3	450	250	255.6	661	112.5	629
				400	713	240.8	807
						282.2	842
						323	870
	50.4		87		231		266

In weak fields, the intensity of magnetization gradually increases, as the temperature falls, till it reaches a maximum, and then gradually decreases. As the field is increased, this maximum recedes towards lower temperatures, and beyond 50 C.G.S., the maximum altogether disappears. These changes are common to nickel steels of 29.24% to 28.32% Ni. In 24.04%, 24.40% and 26.64% Ni, the maximum does not appear from the outset, i.e., as the temperature falls, the intensity of magnetization at first rapidly increases and soon approaches to an asymptotic value for every magnetizing field.

(b) Length change of nickel steels.

The magnetic change of length of nickel steels is given in Table IX and in Fig. 4 c, d, e, f, g, h, i, from which the curves of the change of length for constant fields are obtained and drawn in Fig. 5 a, b, c, d, e, f, g.

TABLE IX.

NICKEL STEEL 29.24%.				NICKEL STEEL 29%.			
$t = -0.3^{\circ}\text{C}$		$t = -70.0^{\circ}\text{C}$		$t = -38.0^{\circ}\text{C}$		$t = -123.3^{\circ}\text{C}$	
H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10^6$	H	$\frac{\partial l}{l} \times 10^6$
4.7	0.3	4.2	0.2	3.4	0.7	10.8	0.2
18.6	1.5	15.3	0.8	12.3	2.8	40.5	1.8
65.1	2.0	46.1	2.2	36.9	4.7	116.5	5.6
118.6	2.7	61.1	3.8	72.3	5.6	241.2	9.3
251.6	4.0	177.7	7.7	175.8	6.5	321	10.6
333	4.8	287.6	9.8	302	7.0	394	11.8
469	5.7	404	11.8	415	7.7		

NICKEL STEEL 28.74%.

NICKEL STEEL 28.32%.

$t = -8.3^{\circ}\text{C}$		$t = -53.0^{\circ}\text{C}$		$t = -45.2^{\circ}\text{C}$		$t = -77.5^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
6.8	0.8	2.7	0.3	15.8	1.4	11.1	0.2
17.2	2.1	9.9	1.6	56.0	2.2	25.7	1.0
72.9	3.5	53.2	5.1	149.3	3.2	34.9	1.4
217.3	4.8	175.3	6.7	248.3	4.0	79.5	2.6
316	5.7	299	7.7	353	5.1	193.3	3.9
430	6.8	418	8.6	443	5.9	286.6	5.1
						417	6.4

NICKEL STEEL 26.64%.

NICKEL STEEL 24.40%.

$t = -39.5^{\circ}\text{C}$		$t = -78.4^{\circ}\text{C}$		$t = -69.2^{\circ}\text{C}$		$t = -97.7^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
45.7	0.3	26.6	0.5	21.4	0.1	28.8	0.5
127.9	1.0	67.8	2.0	47.8	0.2	67.0	1.9
268.0	2.0	166.7	4.8	152.9	2.2	177.5	3.8
442	3.8	266.5	7.0	240	3.5	281	6.6
		390	9.5	336	4.8	389	7.9
				411	5.3		

NICKEL STEEL 24.04%.

$t = -2.0^{\circ}\text{C}$		$t = -64.0^{\circ}\text{C}$		$t = -96.0^{\circ}\text{C}$	
H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$	H	$\frac{\delta l}{l} \times 10^6$
40.9	0.1	43.5	0.5	20.5	0.1
124.4	0.2	114.0	2.0	44.2	1.0
266	0.6	217.3	3.7	125.4	3.4
463	1.1	402	6.6	216.8	5.6
				318	7.7
				412	9.3

From these numbers, we find a parallelism between the change of magnetization and that of the length-change. In weak fields, the change of length gradually increases as the temperature falls, till it reaches a maximum, and then decreases. As the field becomes stronger, the maximum elongation is displaced in lower temperatures, and at last vanishes. These changes are common to nickel steels of percentages higher than 28.32% ; for percentages lower than 26.64%, the elongation for a constant field at first increases gradually and then rapidly, soon approaching an asymptotic value, as the temperature falls.

III. THIRD EXPERIMENT.

In the third series of experiments, the magnetization was measured at different stages of ascending as well as descending temperatures, the measurement of the change of length by magnetization being left for future experiments.

The heating was effected by means of an electric current ; a porcelain tube (external diam.=1.7 cm, internal diam.=1.05 cm, length=47 cm) was covered with a few layers of asbestos paper, and the lower part (36 cm) was wound anti-inductively with a platinum wire 0.4 mm thick at the rate of 2 turns per cm. It was then wrapped in asbestos papers to a thickness of about 5 mm. To the upper end of the porcelain tube, a brass flange was fixed, while to its lower end, a short porcelain cylinder was inserted tightly, so as to arrest air currents. The length of this cylinder was so chosen that when the tube was placed in the right position in the central line of the magnetizing coil, the ovoid occupied the central position of the coil. The mag-

netizing coil was provided with a water-jacketed arrangement, and a coil for the compensation of the vertical component of earth field.

The temperature of the ovoid was measured with a platinum rhodium-platinum junction. One of the junctions was placed in contact with the specimen at a point a quarter of the distance from the upper end of the ovoid, the rest being well insulated with asbestos paper. The interspace between the lead wire and the wall of the porcelain tube was tightly filled with asbestos fibres, and thus protected as much as possible from the convection current. The other junction was arranged as in the second experiment. The thermoelectric current was measured with a d'ARSONVAL galvanometer from KEISER and SCHMIDT, the reading of which was corrected by the authors with a mercury thermometer containing nitrogen below 550°C , and by Professor NAGAOKA and Mr. S. KUSAKABE with the melting point of sodium chloride. A low resistance galvanometer was, at the same time, employed to measure the temperatures lower than 200°C . A simple connection permitted us to pass the thermoelectric current through the d'ARSONVAL or the low resistance galvanometer, as the case might be.

The experiment was conducted in the following order. The adjustments of the magnetometer and the coils, as described in the first experiment, were effected; the heating coil with the specimen was then placed in the right position. The magnetization at the temperature of the room was first determined; then a current from a dynamo was passed through the heating coil, till the temperature of the specimen became constant. The direct effect due to the current in the heating coil was tested by breaking or reversing the current. The small deflection of the mag-

netometer, when there was any, was completely eliminated by altering the form of the lead wires. The demagnetization by reversals, while the heating current was passing, showed no trace of residual magnetism, which indicates that the magnetization due to the heating current was insensibly small. When the temperature became constant, the magnetizations at gradually increasing fields were measured. Another stronger current was next sent through the heating coil, and the same processes were repeated as before. In this way, we measured the magnetization in the stage of ascending temperature, and then that in the descending stage. During each set of observations, the temperature was fairly constant, and even in very unfavorable cases, it did not exceed 2 degrees. The temperature was always noted both before and after each experiment, and the mean was taken. When a series of experiments was finished, the specimen was taken out of the coil, and the compensation tested. Excepting in a few cases, we found the compensation undisturbed; when, however, the disturbance was such as to require a correction, it was uniformly distributed.

In the present experiment, the strength of the heating current and the temperature thereby caused were as follows:—

Current	1.8 amp	2.9	3.8	4.7	5.5
Temperature	100°C	300	600	900	1200

The heating of nickel steels protected in the manner above described showed only a trace of surface-oxidation, if the temperature did not exceed about 800°C. If, however, the temperature was raised to 1200°C, the surface-oxidation became considerable, so that the heating of some specimens was stopped at about 800°C,

if there was nothing of special importance to be gained by heating them above that temperature.

(a) Magnetization of ferromagnetic metals.

The ovoids were first cooled in liquid air ; the observations at ordinary and then at higher temperatures were taken ; the results are given in Table X.

TABLE X.

SWEDISH IRON.

$t=714^{\circ}\text{C}$		$t=736^{\circ}\text{C}$		$t=757^{\circ}\text{C}$		$t=761^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
0.13	49	0.13	40	0.05	50	8.1	11.8
0.26	115	0.79	220	3.29	121	75.5	39.0
0.50	338	18.42	373	29.39	166	188.9	64.5
1.39	533	115.6	493	125.8	211	333	85.3
2.48	597	258.0	542	305	241	437	97.6
22.46	744	398	561	425	250		
258.6	829						
377	834						

$t=772^{\circ}\text{C}$		$t=849^{\circ}\text{C}$		$t=1009^{\circ}\text{C}$		$t=1214^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
52	6.3	128	2.0	99	1.7	92	1.4
140	15.4	300	3.4	280	3.4	286	2.8
281	23.1	443	3.9	439	3.9	442	3.1
444	29.0						

NICKEL.

$t=205^{\circ}\text{C}$		$t=319^{\circ}\text{C}$		$t=362^{\circ}\text{C}$		$t=410^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
1.58	73	1.77	99	32.8	0.8	55	1.1
5.62	190	9.06	176	182.4	5.3	179	4.4
18.83	314	31.0	204	363	9.0	345	6.5
85.7	390	124.5	210	481	10.8	479	8.1
207.4	398	285	213				
334	401	464	215				
447	403						

$t=518^{\circ}\text{C}$		$t=678^{\circ}\text{C}$		$t=874^{\circ}\text{C}$		$t=1149^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
183	3.8	182	3.5	236	4.6	129	2.8
366	6.3	343	5.4	363	5.4	349	5.1
478	7.3	477	6.4	479	5.9	481	5.7

ANNEALED COBALT.

$t=185^{\circ}\text{C}$		$t=307^{\circ}\text{C}$		$t=428^{\circ}\text{C}$		$t=546^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
13.45	49	3.87	45	3.22	22	4.27	57
19.52	96	7.43	112	8.23	83	7.13	141
32.4	198	14.69	319	13.41	185	13.62	406
63.5	325	37.6	570	21.46	307	22.43	547
94.3	411	92.8	770	57.7	514	59.9	710
184.1	568	195.7	913	119.1	662	126.7	832
279.2	677	319	998	240.1	812	253.2	928
376	758	370	1018	379	906	374	978

$t=619^{\circ}\text{C}$		$t=770^{\circ}\text{C}$		$t=919^{\circ}\text{C}$		$t=1060^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
2.48	32	2.40	50	1.26	46	4.14	56
4.79	108	4.45	151	2.55	141	22.03	84
7.88	250	13.21	411	13.83	399	51.1	98
31.31	573	28.15	531	42.20	518	90.0	106
72.1	716	76.0	674	94.4	591	212.5	126
128.5	806	134.0	749	184.9	639	333	136
271.4	909	262.9	823	291.6	665	439	140
378	951	386	856	400	674		

$t=1066^{\circ}\text{C}$		$t=1074^{\circ}\text{C}$		$t=1109^{\circ}\text{C}$		$t=1219^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
2.25	25	7.5	10.6	142	3.0	130	2.2
7.54	44	41.7	19.4	324	6.1	284	3.6
46.8	62	172.1	32.8	446	7.7	443	4.3
149.6	87	343	41.9				
244.1	100	446	45.0				
436	107						

The magnetization of iron and nickel at high temperatures is so well known that it is superfluous to give all the numerical data obtained by our experiment. Hence in the above table, the numbers for iron and nickel are limited to those at very high temperatures, in which they become of interest.

Swedish iron. The magnetization in constant temperature was measured at 20 different temperatures in ascending as well as descending stages; the curves of magnetization were then plotted against the internal field. These curves were cut by an ordinate of constant field. The curves of magnetization in a

constant field plotted against the temperature were thus obtained, and are given in Fig. 6 a.

The change of magnetization of Swedish iron by temperature rise was found to agree well with the results obtained by previous investigators*. The weak magnetization beyond the critical point, as first observed by CURIE, was also noticed. Here the magnetization at different temperatures ranging from 800°C to 1200°C diminishes very slightly as the temperature rises. Thus the meaning of the critical point becomes vague; H. Du Bois defines this temperature to be a point of inflexion in the curve of magnetization to temperature; but it is more convenient to define the temperature as the point of the maximum curvature. The critical temperature so defined is, in the case of Swedish iron, 780°C for $H=400$ C.G.S. It is also to be observed that the critical temperatures for ferromagnetic metals and alloys depend more or less upon the strength of the field.

The magnetization in a stage of descending temperatures falls a little short of the magnetization in ascending temperatures for the same field and temperature. But at ordinary temperatures, they coincide with each other. Combining the above results with those of the magnetizations at the liquid air temperature, we obtain a hysteresis curve with regard to temperature, whose lower range is considerably extended by the present experiment.

Annealed Cobalt. As in the case of Swedish iron, the curves of magnetization to temperature were obtained, and are given in Fig. 6 b.

*) J. HOPKINSON, Phil. Trans. CLXXX, p. 443, 1889; Proc. Roy. Soc. XLIV, p. 317, 1888. LYDALL and POCKLINGTON, Proc. Roy. Soc. LII, p. 228, 1893. D. K. MORRIS, Phil. Mag. XLIV, p. 213, 1897. LEDEBOER, C.R. CVI, p. 129, 1888. TOMLINSON, Proc. Phys. Soc., IX, p. 181, 1888. CURIE, C.R. CXV, p. 805, 1892; CXVIII, p. 796 and 859. WILDE, Proc. Roy. Soc. L, p. 109, 1891. KUNZ, Elekt. Zeits., XV, p. 194, 1894. WILLS, Phil. Mag. L, p. 1, 1900. NAGAOKA and KUSAKABE, Jour. Coll. Sci., XIX, Art. 9, 1904.

The magnetization of annealed cobalt at high temperatures was first observed by Professor NAGAOKA and Mr. KUSAKABE*. The present results generally agree with those obtained by them, but in our case, the cooling in liquid air slightly altered the the magnetic property. In Fig. 6 b, the point corresponding to the magnetization in liquid air is also included.

As the temperature rises from -186°C , the magnetization in a constant field increases at first slowly and then rapidly, till it reaches a maximum at about 300°C , after which it decreases. The magnetization reaches a small minimum, and then begins to increase, and after passing through another maximum, rapidly decreases, reaching its critical point at 1090°C for $H=400$. The descending branch of the curves cuts the ascending branch at about 850°C from downward to upward; but its general course is similar to that of the ascending curve. The minimum point in the ascending branch is about 450°C , and nearly coincides with the singular temperature observed by us in the change of length by magnetization†; at this temperature the sign of the length change is reversed for all fields.

It is also to be noticed that the course of the curve beyond the critical point is nearly parallel to the axis of temperature.

Nickel. The specimen, which was first cooled in liquid air, was heated and the magnetizations at ten different ascending temperatures were observed; since the dynamo stopped, when the temperature attained 1150°C , the magnetizations at decreasing temperatures were not taken as in the other cases, except for the maximum field only.

The curves of the magnetization to the temperature are

*) NAGAOKA and KUSAKABE, loc. cit.

†) HONDA and SHIMIZU, Jour. Coll. Sci., XI, Art. 10, 1903; Phil. Mag. VI, p. 392, 1903.

drawn in Fig 6 c, in which the results of the first experiment were also included. The character of the change of magnetization by heating coincides with the results obtained by the former investigators*. Here the range of the temperature is considerably extended on the negative side of zero temperature. It is remarkable that though the magnetization falls very rapidly near the critical temperature 360°C , its further decrease is very small, and even at 1200°C , a magnetization of about 6 C.G.S. for $H=400$, is still observed. This important phenomenon was first observed by CURIE.

(b) Magnetization of Nickel Steels.

In nickel steels, the magnetic state after cooling in liquid air slightly changes as the time proceeds. In some alloys, it does not return to its initial state, when they undergo a cyclic change of temperatures between -186°C and 1100°C . This change of character is greater in the irreversible alloys than in the reversible.

The magnetization of the alloys at different temperatures presents a striking contrast between the reversible and the irreversible alloys. Some of the interesting results had already been obtained by previous investigators†.

The manner in which the magnetization of the reversible nickel steels changes with the temperature is similar to that of nickel, as given in Table XI.

*) J. HOPKINSON, loc. cit. CURIE, loc. cit. NAGAOKA and KUSAKABE, loc. cit.

†) H. BECQUEREL, C.R. XCIII, p. 794, 1881; J. HOPKINSON, Pro. Roy. Soc., XLVII, p. 23, 1890, and XLVIII, p. 1, 1890; H. Le CHATELIER, C.R., CX, p. 283, 1890 and CXI, p. 454, 1890; H. TOMLINSON, Pro. Roy. Soc., LVI, p. 103, 1894; F. OSMOND, C.R., CXVIII, p. 532, 1894, and CXXVIII, p. 304, 1896, 1899; Ch. Ed. GUILLAUME, C.R., CXXIV, p. 176, 1515, 1897; CXXV, p. 235, 1897; CXXVI, p. 738, 1898; Les aciers au nickel, Paris 1898; E. DUMONT, C.R., CXXVI, p. 741, 1898; L. DUMAS, C.R., CXXX, p. 357, 1900.

TABLE XI.

NICKEL STEEL 70.32%.

$t=11.7^{\circ}\text{C}$		$t=104^{\circ}\text{C}$		$t=410^{\circ}\text{C}$		$t=658^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
0.34	9	0.40	16	0.41	256	35	2.8
1.07	42	1.08	69	1.89	368	132	9.1
1.73	232	1.25	164	8.92	485	276	18.6
4.28	570	1.60	374	31.4	536	476	29.2
12.29	716	2.86	516	64.1	545		
25.09	864	29.5	867	153.5	552		
41.1	947	68.3	944	294.6	565		
76.4	1000	166.1	970	434	573		
193.7	1029	264.6	980				
393	1043	405	989				

$t=733^{\circ}\text{C}$		$t=900^{\circ}\text{C}$		$t=753^{\circ}\text{C}$		$t=1115^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
48	3.9	125	3.8	40	1.7	0.29	28
100	5.6	305	7.9	137	5.0	1.08	171
248	14.3	491	10.3	304	8.5	4.22	491
469	26.7			488	11.0	21.64	908
						56.3	1008
						204.4	1034
						349	1041
						405	1045

NICKEL STEEL 50.72%.

$t=12.0^{\circ}\text{C}$		$t=126^{\circ}\text{C}$		$t=296^{\circ}\text{C}$		$t=410^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
0.54	21	0.95	31	0.76	42	0.40	34
1.91	79	2.90	336	1.27	133	0.70	154
2.70	189	4.30	536	4.44	548	1.67	314
3.29	334	9.54	697	21.39	791	8.81	477
22.68	971	27.40	972	41.9	877	24.43	536
47.5	1123	52.1	1077	91.5	898	57.6	558
108.0	1218	115.9	1146	213.7	913	159.4	565
186.6	1250	215.1	1166	417	921	305	567
309	1263	398	1176			443	579
386	1267						

$t=639^{\circ}\text{C}$		$t=807^{\circ}\text{C}$		$t=634^{\circ}\text{C}$		$t=495^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
21	0.7	31	1.1	31	0.7	30	0.6
113	3.9	206	6.9	136	4.7	98	3.4
267	8.2	487	11.5	322	9.0	345	10.7
490	11.3			484	11.6	482	13.6

$t=431^{\circ}\text{C}$		$t=263^{\circ}\text{C}$		$t=192^{\circ}\text{C}$		$t=12.2^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
12.7	4.7	0.06	46	0.07	34	0.20	26
34.7	11.5	0.20	169	0.18	432	0.49	87
101.6	31.2	0.45	586	0.70	649	0.77	355
245.1	46.2	85.3	941	6.53	951	0.94	582
402	58.7	269.8	949	24.20	1048	45.7	1235
478	65.1	408	952	72.0	1069	143.0	1259
				253.5	1078	261.7	1264
				390	1082	378	1267

NICKEL STEEL 46%.

$t=12.3^{\circ}\text{C}$		$t=131^{\circ}\text{C}$		$t=267^{\circ}\text{C}$		$t=345^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
0.78	22	0.78	28	0.59	31	0.42	38
1.83	60	2.56	144	1.29	96	0.82	112
3.40	190	3.21	319	2.71	403	2.51	227
7.49	549	5.11	521	5.40	561	4.59	380
9.87	706	9.71	751	15.11	704	13.46	495
17.70	913	22.80	943	34.8	778	40.2	562
42.9	1113	46.6	1047	78.9	834	135.3	588
80.3	1201	106.6	1114	213.4	851	253.9	593
195.4	1260	264.4	1140	317	852	431	597
375	1276	381	1146	409	854		

$t=411^{\circ}\text{C}$		$t=456^{\circ}\text{C}$		$t=624^{\circ}\text{C}$		$t=488^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
17	2.8	47	0.6	56	2.0	87	4.5
50	6.2	105	2.8	240	7.3	234	8.7
137	14.6	305	10.0	387	11.6	385	12.5
477	40.8	483	14.2	479	13.4	475	14.2

$t=371^{\circ}\text{C}$		$t=318^{\circ}\text{C}$		$t=210^{\circ}\text{C}$		$t=33.2^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
12.3	30	0.59	31	0.72	27	1.62	49
18.9	45	1.51	209	1.35	80	2.90	132
45.6	91	5.24	400	2.14	204	5.94	512
190.6	143	11.41	490	5.86	527	17.62	827
347	168	45.2	592	50.95	887	69.6	1120
459	183	198.0	626	169.4	964	161.8	1217
		329	631	284	974	280	1243
		425	638	399	979	369	1252

NICKEL STEEL 36%.

$t=10.0^{\circ}\text{C}$		$t=161^{\circ}\text{C}$		$t=225^{\circ}\text{C}$		$t=259^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
1.24	30	1.06	55	5.7	33	31.6	0.7
3.51	119	2.23	191	17.8	45	152.2	6.0
4.32	232	3.99	308	48.2	54	355	13.2
7.79	499	12.89	461	259.0	84	497	16.6
32.9	863	54.9	547	478	102		
64.2	954	135.1	563				
176.2	1021	276.5	572				
299	1035	437	578				
419	1039						

$t=447^{\circ}\text{C}$		$t=828^{\circ}\text{C}$		$t=423^{\circ}\text{C}$		$t=303^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
96	3.3	105	4.7	31	1.8	79	4.2
251	8.4	251	10.5	103	5.7	232	10.5
491	13.5	488	17.1*	283	12.9	363	14.7
				484	18.1	482	17.8

$t=218^{\circ}\text{C}$		$t=182^{\circ}\text{C}$		$t=145^{\circ}\text{C}$		$t=10.0^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
30.5	14.7	0.26	54	0.21	42	0.31	32
77.4	23.9	1.54	198	0.46	127	0.71	118
160.2	35.5	8.08	335	1.51	242	1.66	314
320	55.3	20.58	364	6.46	459	4.88	556
481	70.6	71.4	379	49.6	582	16.15	801
		250.7	391	151.4	592	112.1	1013
		447	401	292.3	597	247.9	1027
				428	602	302	1028
						375	1029

*) In this case, the compensation of the magnetizing coil was found to be disturbed and therefore the disturbance was equally distributed over the whole set. This small increase of magnetization is probably due to the impaired compensation.

Comparing the above values for ordinary temperature with the corresponding values in the first experiment, we notice that except with 36% nickel steel, the magnetizability of these alloys had slightly changed by the repeated heating and cooling, which the alloys underwent, since the end of the first experiment.

From these results, the curves of magnetization to temperature are obtained and given in Fig. 7 a, b, c, d. In these figures, we have also included the results obtained in our first and second experiments. As seen from the figures, the diminution of magnetization, after the critical point is reached, is very slight; and to judge from the course of the curve, it seems probable that the magnetization does not altogether vanish, till the melting points are reached.

The curves of magnetization at a constant field in the ascending and descending stages of temperature do not exactly coincide with each other when the range of temperature is large, the two curves thus enclosing a small area between them.

As the critical points of these nickel steels for $H=400$, we give the following values:—

Alloys	70.32%	50.72%	46%	36%
Ascending branch	660°C	490°C	412°C	255°C
Descending branch	—	460°C	395°C	240°C

These values nearly coincide with those of M. OSMOND and L. DUMAS. Thus the critical point decreases with the percentage content of nickel.

The manner, in which the magnetization of irreversible nickel steels changes with temperature, is very striking. The observed values are given in Table XII.

TABLE XII.

NICKEL STEEL 29.24%.

$t=11.6^{\circ}\text{C}$		$t=140^{\circ}\text{C}$		$t=210^{\circ}\text{C}$		$t=352^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
3.21	30	5.83	31	11.27	57	9.87	56
9.33	103	12.57	109	18.51	162	18.10	161
14.20	200	29.8	299	29.1	276	31.3	275
22.35	355	74.3	433	68.0	428	69.4	399
48.3	507	169.5	566	164.7	566	167.7	518
79.0	604	329	678	280.5	646	308	595
150.5	723	449	729	442	713	445	639
244.2	810						
345	870						
417	902						

$t=499^{\circ}\text{C}$		$t=547^{\circ}\text{C}$		$t=799^{\circ}\text{C}$		$t=466^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
20.3	6.2	51	1.8	51	2.0	52	2.2
56.0	18.9	168	6.1	140	4.8	152	5.8
183.2	57.3	357	10.9	308	9.3	311	12.8
304	80.4	495	13.9	494	12.3	494	13.7
410	94.6						
487	102.5						

$t=299^{\circ}\text{C}$		$t=192^{\circ}\text{C}$		$t=93^{\circ}\text{C}$		$t=12.0^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
31	1.1	31	1.4	45	2.2	0.21	46
105	4.9	103	5.1	107	5.8	1.63	107
256	10.1	254	10.5	272	13.2	5.15	182
376	12.8	375	13.6	494	20.6	27.91	250
497	15.5	494	16.2			95.6	265
						188.7	275
						334	286
						477	295

NICKEL STEEL 29%.

$t=14.3^{\circ}\text{C}$		$t=168^{\circ}\text{C}$		$t=268^{\circ}\text{C}$		$t=383^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
4.35	3	5.95	23	7.43	21	9.85	44
5.31	71	12.60	86	14.55	71	26.24	153
12.31	214	19.61	176	23.40	173	49.3	230
20.76	367	30.5	254	36.1	257	109.7	314
29.1	432	64.5	353	115.4	407	231.1	387
57.5	585	208.7	503	281.5	512	441	446
125.2	717	323	561	434	561		
238.0	815	436	600				
416	889						

$t=465^{\circ}\text{C}$		$t=515^{\circ}\text{C}$		$t=644^{\circ}\text{C}$		$t=799^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
16.9	16	45.7	2.3	54	2.0	94	2.5
45.4	50	161.3	10.8	280	7.7	282	3.6
93.3	96	340	22.9	475	10.3	477	8.9
212.4	161	473	29.9				
321	192						
448	217						

$t=601^{\circ}\text{C}$		$t=405^{\circ}\text{C}$		$t=206^{\circ}\text{C}$		$t=12.3^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
65	2.3	94	3.4	86	3.4	0.41	78
247	7.3	232	7.4	229	8.0	1.36	182
479	10.4	344	9.0	358	10.7	4.54	302
		476	10.8	473	12.2	17.32	381
						138.4	412
						369.9	426
						466	428

NICKEL STEEL 28.74%.

$t=12.3^{\circ}\text{C}$		$t=87^{\circ}\text{C}$		$t=143^{\circ}\text{C}$		$t=228^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
3.09	22	3.99	21	5.66	32	3.63	14
7.20	67	8.26	52	10.47	92	10.53	61
14.04	192	12.79	114	15.30	177	16.50	163
21.16	340	20.17	244	23.95	310	25.82	316
51.9	569	27.27	331	47.5	426	54.9	468
127.0	777	52.0	460	75.9	518	126.8	611
225.7	896	82.6	564	203.1	701	249.0	722
307.2	955	185.1	716	318	784	333	766
422	1015	313	820	436	841	450	813
		429	882				

$t=327^{\circ}\text{C}$		$t=418^{\circ}\text{C}$		$t=497^{\circ}\text{C}$		$t=634^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
8.01	38	6.45	41	23.6	5.9	83	2.5
16.46	167	13.19	111	52.4	14.6	214	6.9
25.33	298	22.50	193	97.1	28.4	239	10.2
59.9	461	33.6	256	158.9	42.6	507	12.6
109.9	556	68.5	352	364	79.4		
224.1	659	117.3	428	506	93.9		
365	726	266.7	527				
443	752	446	584				

$t=795^{\circ}\text{C}$		$t=399^{\circ}\text{C}$		$t=101^{\circ}\text{C}$		$t=24.2^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
60	2.1	98	4.2	24	1.1	0.10	41
157	5.2	262	9.7	107	6.6	3.85	207
342	9.6	511	14.3	258	14.6	23.07	285
511	12.0			507	24.2	96.1	303
						257.5	319
						490	334

NICKEL STEEL 28.32%.

$t=12.5^{\circ}\text{C}$		$t=130^{\circ}\text{C}$		$t=300^{\circ}\text{C}$		$t=453^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
3.28	21	5.16	26	7.43	33	12.45	28
6.67	75	9.36	77	17.01	156	28.82	72
14.58	183	17.05	233	25.74	293	45.6	114
24.56	328	25.68	348	47.2	434	89.1	185
41.4	438	40.8	432	95.6	582	189.2	287
65.6	555	81.7	579	194.3	697	314	339
132.1	713	183.5	734	318	778	469	401
266.6	861	315	833	439	824		
420	962	423	872				

$t=504^{\circ}\text{C}$		$t=649^{\circ}\text{C}$		$t=818^{\circ}\text{C}$		$t=581^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
22	1.4	114	4.5	120	3.9	109	3.9
52	3.9	217	7.2	263	7.9	246	7.9
276	24.3	516	12.5	513	11.4	385	10.8
506	39.5					510	13.7

$t=387^{\circ}\text{C}$		$t=200^{\circ}\text{C}$		52°C		12.8°C	
H	I	H	I	H	I	H	I
105	4.8	105	5.1	46	3.7	3.19	20
216	8.2	215	9.1	111	8.4	18.38	36
367	11.7	341	12.5	388	23.1	37.8	46
512	14.2	511	15.9	513	28.8	125.2	72
						289	102
						492	126

NICKEL STEEL 26.64%.

$t=15.3^{\circ}\text{C}$		$t=121^{\circ}\text{C}$		$t=239^{\circ}\text{C}$		$t=392^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
2.55	10	5.20	25	6.38	27	5.03	55
10.22	65	9.02	59	13.88	93	9.42	138
16.87	154	16.46	163	19.21	209	13.93	226
25.32	292	24.45	297	26.04	341	24.14	364
37.4	402	33.2	384	39.1	482	60.6	553
57.4	581	50.2	533	54.1	613	111.9	665
105.3	737	104.9	738	100.9	755	226.4	774
180.1	876	179.4	867	192.3	882	420	849
271.1	976	290	969	330	982		
406	1064	401	1035	395	1001		

$t=463^{\circ}\text{C}$		$t=517^{\circ}\text{C}$		$t=665^{\circ}\text{C}$		$t=828^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
7.27	28	50	2.4	104	3.9	79	3.5
15.03	63	204	10.3	248	8.8	301	9.8
28.18	121	484	20.2	484	13.9	481	13.6
40.5	167						
101.1	297						
216.1	417						
352	480						
439	538						

$t=514^{\circ}\text{C}$		$t=401^{\circ}\text{C}$		$t=227^{\circ}\text{C}$		$t=80^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
103	4.5	123	5.4	124	5.2	113	5.6
301	10.3	303	10.8	301	10.5	301	12.4
480	14.4	479	14.8	480	15.0	479	16.6

NICKEL STEEL 24.40%.

$t=13.0^{\circ}\text{C}$		$t=101^{\circ}\text{C}$		$t=190^{\circ}\text{C}$		$t=366^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
3.89	14	8.42	37	12.11	71	9.00	58
12.35	66	19.06	155	19.50	184	16.20	187
20.60	171	27.62	282	27.16	304	23.75	331
27.75	297	48.4	450	49.5	508	40.5	475
56.09	497	81.7	618	61.3	579	62.9	589
126.5	744	152.4	775	148.3	791	132.0	733
184.9	837	229.5	864	261.2	903	213.3	805
296	941	308	926	420	988	312.0	856
400	1009	419	991			427	895

$t=466^{\circ}\text{C}$		$t=490^{\circ}\text{C}$		$t=392^{\circ}\text{C}$		$t=207^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
5.25	35	8.48	25	12.42	30	10.39	37
10.72	89	18.47	60	15.66	73	23.25	96
25.72	234	39.2	138	40.5	125	37.78	167
44.7	338	73.2	226	80.3	230	76.7	302
113.7	521	145.4	343	165.8	362	138.5	438
244.9	645	296	456	279.4	460	272.2	575
442	724	458	516	455	542	447	661

$t=14.2^{\circ}\text{C}$		$t=237^{\circ}\text{C}$		$t=410^{\circ}\text{C}$		$t=490^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
5.78	32	8.17	28	12.55	33	14.36	29
13.39	86	16.48	61	23.55	68	37.3	90
20.82	155	31.36	126	38.2	126	90.4	209
47.2	375	74.9	267	73.2	201	184.1	327
77.0	543	155.6	425	105.2	270	342	423
164.8	722	309	569	230.6	413	434	465
260.0	797	449	631	334	489		
412	880			447	538		

$t=542^{\circ}\text{C}$		$t=591^{\circ}\text{C}$		$t=851^{\circ}\text{C}$		$t=1000^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
29.2	13	56.7	2.0	57.1	1.7	105	2.5
98.8	50	166.5	5.2	152.0	4.1	305	6.0
338	128	308.2	8.2	308.3	7.4	483	7.3
472	146	483	10.5	486	8.7		

$t=1200^{\circ}\text{C}$		$t=861^{\circ}\text{C}$		$t=212^{\circ}\text{C}$		$t=14.6^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
290	3.4	105.3	2.1	64.4	5.1	19.6	25
448	3.6	304	4.7	165.4	8.9	46.2	83
480	3.7	481	5.4	323	11.9	92.8	124
				485	13.8	193.6	176
						351	214
						464	233

NICKEL STEEL 24.04%.

$t=10.1^{\circ}\text{C}$		$t=182^{\circ}\text{C}$		$t=287^{\circ}\text{C}$		$t=452^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
2.44	6	3.68	13	3.48	14	3.81	27
10.74	42	11.43	54	12.36	77	12.27	123
27.60	230	20.48	138	18.63	193	24.91	254
35.6	306	26.97	270	23.06	313	47.7	372
58.2	520	39.1	386	33.2	427	71.9	452
80.6	641	58.9	552	51.8	592	164.3	602
115.0	756	90.7	703	95.7	760	271.2	673
185.6	888	174.7	875	183.4	886	447	745
276.2	985	284.5	982	275.8	954		
393	1060	395	1046	383	1002		

$t=531^{\circ}\text{C}$		$t=586^{\circ}\text{C}$		$t=717^{\circ}\text{C}$		$t=604^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
41	1.9	101	3.4	124	4.6	64	3.4
184	7.9	268	7.7	348	10.0	236	7.7
370	13.7	487	11.5	487	12.1	411	11.3
490	16.2					489	12.9

$t=502^{\circ}\text{C}$		$t=274^{\circ}\text{C}$		$t=193^{\circ}\text{C}$		$t=11.3^{\circ}\text{C}$	
H	I	H	I	H	I	H	I
79	3.0	50	2.8	34	1.8	57	2.8
250	9.0	151	7.7	102	5.7	165	8.9
392	11.9	352	14.1	310	12.9	286	13.8
487	13.8	487	16.6	494	16.5	484	18.9

From these values, the curves of magnetization to temperature are obtained and drawn in Fig. 7 e, f, g, h, i, j, k. In these figures, we have included the results obtained in the first and second experiments.

Here we also notice that except with 28.74%, the magnetizability of these alloys had considerably changed by the heating and cooling, which the alloys underwent since the first experiment. Hence in some of the figures, the portions corresponding to the first experiment were displaced parallel to themselves so as to form closed curves. Thus the displaced portions are given in dotted lines.

As the temperature gradually rises from -186°C , the magnetization of 29.24% Ni diminishes at first slowly, then rapidly, and after passing through an inflexion point, the diminution becomes slow. The curve, passing through a second inflexion point, begins to descend very rapidly, as the critical temperature is approached. If this temperature be passed, the diminution of the magnetization by heating is very small, so that the curve is nearly parallel to the axis of temperature. From the course of the curve, it seems probable that the magnetization does not altogether vanish, till the melting point of the specimen is reached. As the temperature is next gradually reduced, the increase of magnetization is very small; this state continues, till the temperature falls to about 100°C ; then the increase becomes very rapid. For example, in $H=400$ C.G.S., the intensity of magnetization at the descending temperature is only 20 C.G.S. for a temperature of 80°C , but it amounts to 200 for -20°C , and at -60°C , it increases to 790. Thus the magnetization of the specimen displays a remarkable difference between the ascending and descending branches of the curve.

The above manner, in which the magnetization is changed by temperature, is common to all other irreversible nickel steels. As the percentage of nickel decreases, the concave portion of the ascending branch becomes fainter and fainter; and with 24.40% and 24.04% Ni, it almost vanishes for strong fields. Apparently, the forms of the two curves for nickel steels of 29.24% and 24.04% Ni, are widely different from each other; but if we compare the forms of the curves of two consecutive nickel steels, we can trace transition stages from one form to the another.

The critical temperatures of the alloys for $H=400$ C.G.S. are given in the following table:—

Alloys	29.24%	29%	28.74%	28.32%	26.64%	24.40%	24.04%
Ascending branch	530°C	530°C	530°C	510°C	510°C	580°C	520°C
Descending branch	70	140	80	50	10	130	40

Thus in the ascending branch, the critical temperatures of these irreversible nickel steels are nearly equal, except with the last but one. The above numbers fairly coincide with those obtained by M. OSMOND, except with 24.40% Ni. With this alloy, the critical temperatures are greater, in our case, by about 50°C for the ascending branch and 100°C for the descending, than in the experiment by OSMOND. The values given by L. DUMAS for the first four of these alloys are considerably less than those obtained by us; but for the remaining alloys, the contrary is the case. These discrepancies may probably be due to the previous history of the alloys.

It remains to mention a singular phenomenon. If at a point in an ascending branch of the temperature-cycle, the temperature be reduced to the ordinary, the path is utterly different from the

ascending one. If, however, the temperature be again increased to its former value, the path nearly coincides with the former one; the further increase of temperature diminishes the magnetization in such a manner that the magnetization is not interrupted by the cooling process. An instance is seen in Fig. 7 j. Hence in irreversible nickel steels, the magnetization at ordinary temperature can have *any value whatever* within a given limits, if the cooled specimens be heated to a suitable temperature. Becquerel who first studied the magnetic properties of irreversible nickel steels, found that in the alloy, there were two states of stable equilibrium; but according to our results, there are an infinite number of such states, a fact which may possibly prove to be important in the theory of molecular magnetism.

Comparing the magnetization at different temperatures in these nickel steels, we notice that the critical temperature in the descending branch of the temperature-cycle generally becomes less, as the percentages of nickel decreases. As the content of nickel diminishes from 70.32% to 26.64%, the critical temperature falls from several hundred degrees to the ordinary temperature. It is then highly probable that 25% nickel steel, which is feebly magnetic both at ordinary and liquid air temperatures, would become strongly magnetic, if the cooling should be pushed still further. If it once become strongly magnetic by cooling, it may preserve this property, after the alloy is heated to the ordinary temperature. It will be interesting to investigate, whether other non-magnetic alloys, which consist of a magnetic and a non-magnetic metal, would display a similar phenomenon on being cooled to a sufficiently low temperature.

The fact that the two strongly magnetic metals form a non-magnetic metal is then nothing more than the lowering of the

critical temperature of the alloy to the ordinary temperature. Owing to some changes occurring in the molecular configuration during the process of fusion of the constituent metals, the critical temperature of the alloy in the descending branch of the temperature-cycle falls to a low temperature, and therefore the alloy behaves as a weakly magnetic or non-magnetic alloy at ordinary temperature. The same remark will also apply to a non-magnetic alloy which consists of a magnetic metal and a non-magnetic ones. The above view is also favored by the fact that in irreversible alloys, the hysteresis-loss at ordinary temperature is markedly small, which corresponds to the hysteresis of iron or nickel at high temperatures, but its value at a low temperature considerably increases, corresponding to the hysteresis of the same metal at ordinary temperature.



Fig. 1. a.



Fig. 1. b.

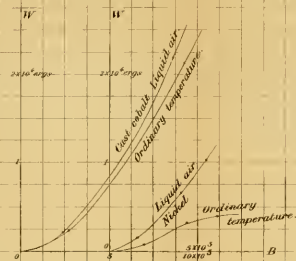


Fig. 2. a. Nickel steels.

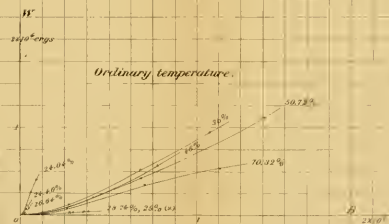


Fig. 2. b. Nickel steels.

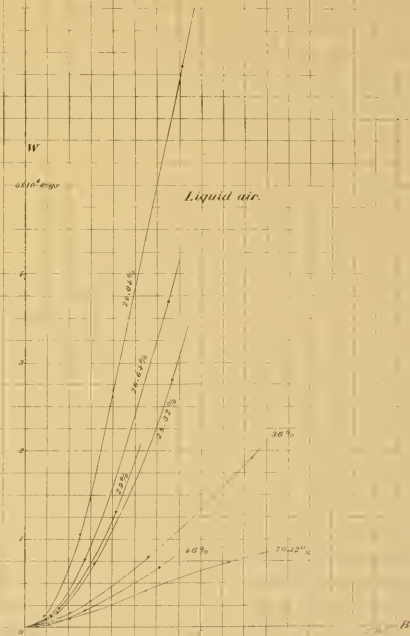


Fig. 3, a.

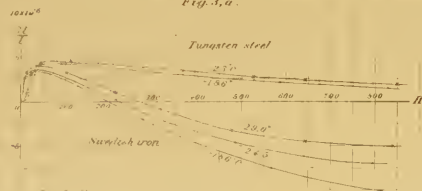


Fig. 3, b.

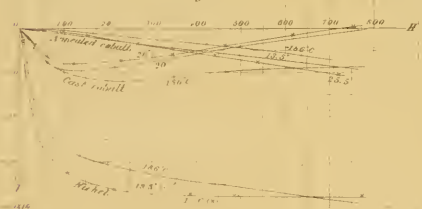


Fig. 4, a; 70.32%, 50.72% Ni

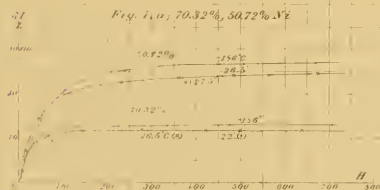


Fig. 4, b; 36% Ni.

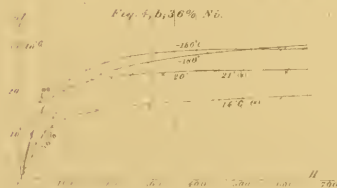


Fig. 5, c; 20.24% Ni.

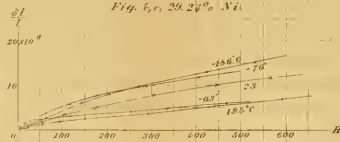


Fig. 5, d; 20% Ni.

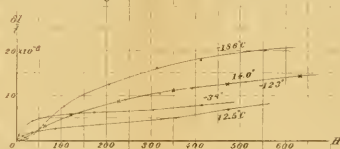


Fig. 5, e; 28.72% Ni.

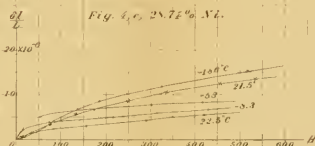


Fig. 5, f; 28.32% Ni.

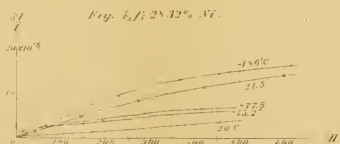


Fig. 5, g; 26.64% Ni.

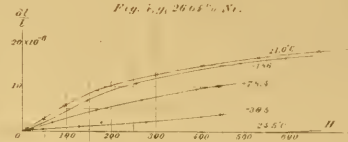


Fig. 5, h; 24.10% Ni.

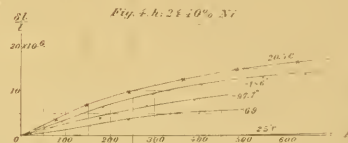


Fig. 5, i; 24.04% Ni.

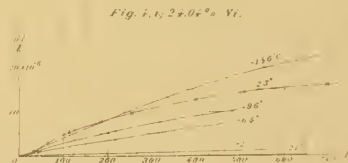


Fig. 5, a, 29.25% Ni.

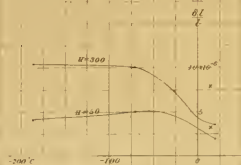


Fig. 5, b, 29% Ni.

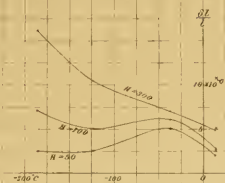


Fig. 5, c, 28.75% Ni.

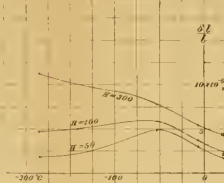


Fig. 5, d, 28.32% Ni.

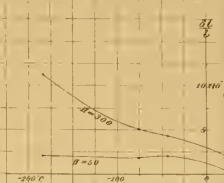


Fig. 5, e, 26.65% Ni.

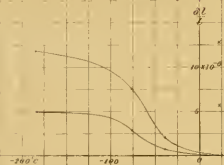


Fig. 5, f, 25.40% Ni.

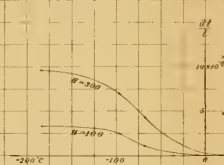
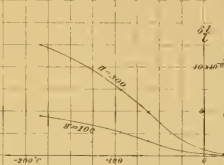


Fig. 5, g, 25.05% Ni.



1

Fig. 6, a
Swedish iron.

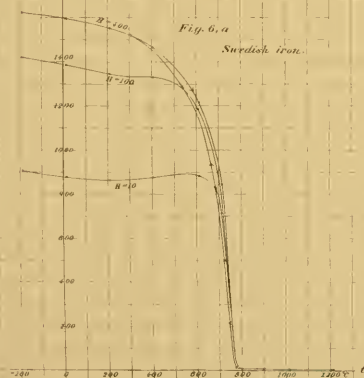


Fig. 6, b.
Cobalt (Anvers)

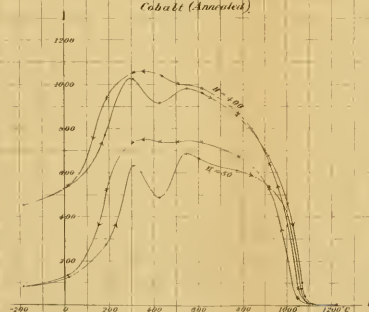
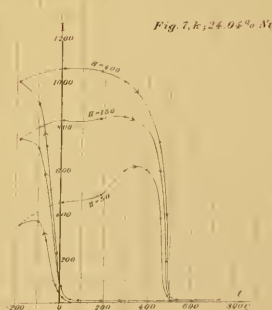
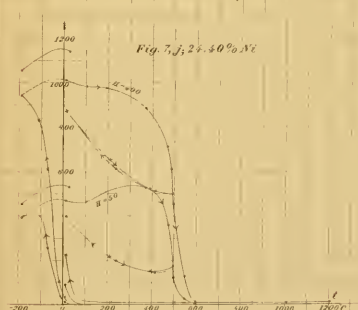
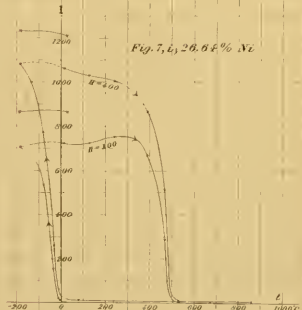
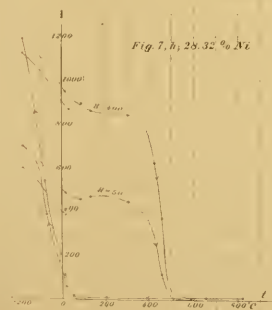
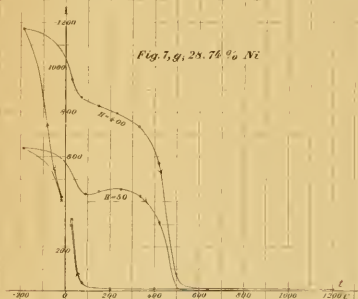
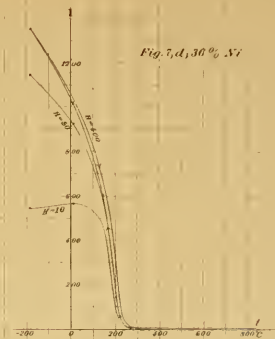
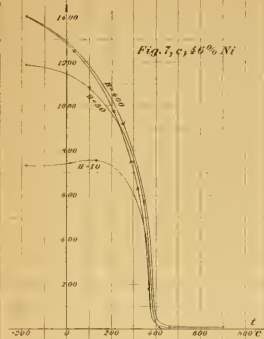
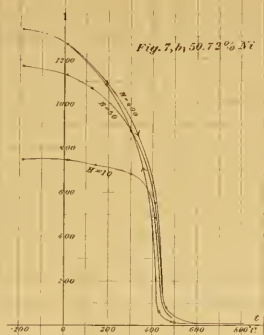
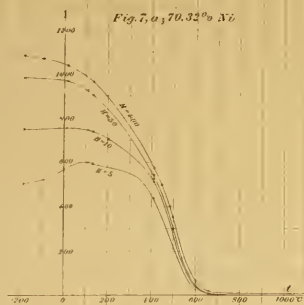


Fig. 6, c.
Nickel.





On a New Cestode Larva Parasitic in Man

(*Plerocercoides prolifer*).

By

Isao Ijima, *Rig., Ph. D., Rig.-Hak.*,

Professor of Zoölogy, Imperial University, Tōkyō.

With one plate.

The remarkable Cestode larva to be described in this paper probably belongs to the Bothriocephalidæ. It may be called a Plerocercoid and the name, *Plerocercoides prolifer*, is given simply because it is desirable that there should be a distinctive name for practical use.

For the opportunities of studying this most interesting parasite I am indebted to Dr. J. KONDŌ, Professor of Surgery in the College of Medicine, Tōkyō Imperial University, and also to his assistants, Drs. H. SHIODA, M. YAMAMURA and K. SUGI.

The patient who harbored, especially in the subcutaneous tissues, enormous numbers of the worm in question, was a woman, YAE TANAKA by name, and resident either in Tōkyō or in its immediate vicinity. Her occupation had been that of a weaver until she was married to a dealer in old furniture, occupations which place her decidedly in the lower class of society. In the spring of 1904, she came to the University hospital for the treatment of an in-

guinal hernia. Dr. SHIODA tells me that the cause of the hernia, which was on the left side, was traceable to the presence of the parasites in the region of the Ligamentum Poupartii. The patient was then thirty-three years of age. Aside from the affliction complained of, what at once attracted the attention of the medical attendants was the peculiarly swollen state of the integument which bore scattered spots of acne-like appearance. This abnormal state of the skin extended over nearly the entire body, except, so far as I could roughly observe, on the face and the upper extremities, but was most strikingly noticeable on the left thigh. This was excessively swollen and had very much the appearance of elephantiasis, though the skin and the underlying tissues were quite soft so that they hung down by their own weight and could be grasped in a flaccid mass by the hand.

Of the statements made by the patient I will refer to only a few points. When twenty-five years old, she had had a tape-worm; but that surely had nothing to do with the present parasitic disease. The dermal affection was said to have been first felt in her thirty-first year, i.e., about two years previously to her coming to the hospital. It had apparently given the patient no trouble beyond that imposed upon motion by the swollen thigh and the itching of the skin in parts where a pimple-like hardening made its appearance. Scratching with the nails in order to appease the itching had led to breaking of the skin at the spot, from which could then be pressed out a soft whitish mass together with some fluid. A number of small scars, seen more especially on the breasts, attested to abrasions thus effected apparently not long before. Details of clinical and pathological observations will doubtless be given in a forthcoming report by Professor KONDŌ.

In the examination of preparations made of the skin taken from the left thigh, I was taken in consultation by Mr. YAMAMURA. It was not long before I was convinced of the presence, in the connective tissue, of numerous encapsuled worms, the Cestode character of which was evident from the calcareous bodies contained in the parenchyma.

Subsequently on two occasions, July 9th and 24th, 1904, I was present at surgical operations undertaken to relieve the patient of the superfluous tissues and to procure fresh material for study and experiments. Each time a very large piece of the skin and the underlying tissues was excised from the left thigh. I should think that altogether several pounds' weight of them was removed during the patient's stay in the University hospital.

Of quite an unusual appearance were the subcutaneous tissues when freshly taken from the affected limb. At places several centimeters thick, they were moderately rich in panniculus adiposus and extraordinarily so in lymph. The latter swelled the connective tissue between the panniculi, giving it a slimy or gelatinous appearance and consistency. The slimy character seemed to be more manifest in the deeper parts. The lymph exuded copiously from the cut surfaces. The numerous capsules with the worm within were observable as whitish objects isolated or in clusters, in all parts of the tissues.

In fig. 1 (Pl.) I have shown, in natural size, a vertical slice of the skin and subjacent parts taken from the lateral side of the thigh and hardened in spirit. In the large piece, from which the slice was taken, is represented nearly the entire thickness of the tissues between the skin surface and the underlying muscles. I may say that this thickness measures 30-60 mm., notwithstand-

ing the fact that the hardening process has contracted the subcutaneous connective tissue, through loss of the lymph, into dense fibrous bundles, so that it no longer bears a semblance of what it was in the fresh state. The corium in the same piece may be said to be 3–6 mm. thick; it seems to be on the whole considerably thicker than in the normal state. In the figure above referred to, the lightly shaded subcutaneous spaces represent the adipose tissue, which, when blackened with osmic acid, stood out in sharp contrast to the connective tissue bundles and the capsules containing the worm.

The Worm Capsule.—The worm capsules of various sizes occur in abundance in all parts of the subcutaneous tissues and less abundantly in the corium. They were also observed in some numbers in the intermuscular connective tissue but not in the muscles themselves, so far as such observation could be made on parts incidentally exposed during the surgical operation. In the corium the capsule may be situated so close to the epidermis that the latter is externally raised into an acne-like prominence. On a piece of the preserved skin about 2 inches square I find at least four such prominences, which, as seen on the surface, appear smooth and less pigmented than the surrounding parts. Capsules in so superficial a position might without difficulty be caused to break through the epidermis by force applied from the exterior. The “soft whitish mass” which the patient pressed out after scratching certain itchy spots, could have been nothing else than the parasite which was present in the ruptured capsule.¹⁾

1) The escape of the worms from the host, in the manner indicated, is to be looked upon as merely an accidental occurrence dependent upon the exceptionally superficial situation of their capsules; it was surely not an event natural to the species' life-history.

In shape the capsules are generally subspherical or ovoid. While the smallest of them are considerably less than 1 mm. in diameter, others measuring 1–2 mm. or more across are of quite common occurrence. One of the largest I have taken was of an elongate shape, $2\frac{1}{2}$ mm. broad and 8 mm. long. Another measured 3 mm. by 6 mm. The larger capsules are found only in the subcutaneous parts, not in the corium. In the fresh state I could isolate the capsules without much trouble by tearing and cutting them off from the surrounding loose tissues.

The capsular wall (fig. 23), consisting of a dense feltwork of connective tissue fibers of the host, may reach nearly $\frac{1}{2}$ mm. in thickness. In sections the capsules may appear not unlike a transversely cut blood-vessel on account of the tough and compact looking wall. Seen under the hand-lens, the internal surface of the wall looks smooth. In some large cysts the internal cavity was seen to be traversed by a branching pillar-like trabecula, the presence of which may be explained by supposing an enlargement of the cavity to have taken place around a strong connective tissue bundle or bundles. Under the microscope the internal surface of the wall either shows no special limiting structure or is lined with a deposit of what may be considered to be a granular coagulum or some tissue debris, the same as that which is found free in the cavity together with the worm.

Abundance of the Parasite.—An approximate idea of the enormous numbers of the parasite which infested the patient may be obtained from the fact that in the vertical section of fig. 1, presenting a surface of about 11 sq. cm., there can be counted nearly 60 capsules which had been cut by the knife. So far as concerns the most thickly infested parts of the patient's left

thigh, I should consider it a moderate estimate to allot on an average one capsule to every 20 sq. mm. of such cut surface or to every 100 cu. mm. of the infested tissues. This would give 1000 capsules to a mass of 100 cu. cm. of the same, in other words, to a mass of the subdermal tissues represented on the skin-surface by an area of 25 sq. cm., assuming the depth to be 4 cm. At any rate, I believe it to be in no way an exaggeration to say that there must have been considerably over ten thousand capsules in the left thigh alone.

Worms without Capsule.—Here I may mention that not all the worms were found in the encapsuled state. During the surgical operation a number of them were discovered free, so to say, in the connective tissue. This mode of occurrence was placed beyond doubt by observations of cases in which some worms, with moderately extended body and without a trace of an enclosing capsule, were found lodged right within a film of the fresh connective tissue when the latter was carefully distended between the fingers. It is noteworthy that these free worms were always small and of the simple slender shape, — typical Plerocercoids such as those represented in fig. 2 *a-c*; they were never so plump-bodied as are many confined within capsules. This fact indicates that it is only the comparatively younger individuals that are sometimes found free in the connective tissue.

Movements of the Worm; the Head.—Living worms liberated from the capsule by cutting this open and left in the warm lymph, showed slow movements, alternately extending and contracting, but effecting little or no change in position. On cooling the movements subsided, leaving the worm in a more or less

contracted condition. So likewise with all the worms which I have thrown into the cold (summer temperature) physiological fluid. However, for some time afterwards, motion could be restored by imparting a little warmth to the medium they were in. With such worms as I had kept in the physiological fluid, after about four hours had elapsed, my attempt at reviving them into motion was only partially successful; many of them then seemed to be nearly or quite dead, showing on the surface pustule-like swellings due to imbibition of the fluid into the parenchyma.

Observing the moving worms under the microscope, the narrower end of the body—undoubtedly the head—showed most motion. This consisted chiefly in evagination and invagination of the extreme end as well as in a shortening and lengthening of the parts. In the more active individuals the head-end was seen now and then to evaginate and elongate to the fullest extent, exposing the rounded extreme tip of the head (as in fig. 18). At other times there was perceivable on the tip a small depression or concavity, which, especially when the terminal parts of the head was somewhat broadened after a narrow neck-like part as was frequently the case for the time being, reminded me of the single terminal sucker known from the fish Bothriocephalid *Cyathocephalus* KESSL. But that depression was evidently simply due to invagination of the extremity of the head, for I have frequently seen it gradually but totally disappear as the head-end prolonged itself into a simple finger-like shape, losing the terminal broadening which might be observed so long as the invagination was present. The completely everted, slender head-end moved about as if feeling for something and at the same time generally started a rather lively peristaltic motion which traveled backwards for some distance. Altogether the movements are such

as would effectually assist the worm in penetrating into and shifting through the tissues of the host. In several cases I have succeeded in killing the worms with the head completely or nearly completely everted and protruded, by suddenly pouring on hot corrosive sublimate (figs. 18, 21).

The broad posterior parts of the body showed at most slow vermiform movements, keeping up nearly all the time a more or less strong indentation or invagination at the extreme hind end. Attempts to bring fresh worms into full extension by applying pressure between glasses, invariably failed.

From what I have seen of the moving head I must say that this is entirely destitute of any definitely formed and permanent organ of attachment. Examinations of well extended heads laid out into serial cross-sections have failed to reveal anything like bothria or suckorial grooves characteristic of the Bothriocephalidæ. It can certainly not be denied that the terminal invagination, an inconstant and temporary condition though it be, may under circumstances play the part of a sucker.

Division of the Worm within the Capsule.—With the smaller capsules it is the rule that they contain each a single worm. The same may sometimes be the case with the larger capsules also, but these more frequently contain two or more worms or pieces of the worm. From one of the largest capsules I have seen, five worms were obtained, and in another case seven (fig. 2). This increase in number is explained by the propensity of the worm to divide by transverse fission at a certain stage of its growth. Very frequently the worm body shows a constriction or constrictions at which places it is easily torn apart. In many cases I could not prevent this separation of the body taking place

during the process of removal from the capsule, however carefully this was done. In other cases a slight pressure between glasses sufficed to effect the separation at the constricted place. After all I have observed, there can be no doubt that the worm has the power of dividing and multiplying on its own account within the capsule. Thus the worm shown in fig. 5 may be looked upon in the light of one which is about to divide into two in the middle. I return to this point again soon.

Size and Shape : Budding.—While many of the worms are very small and filiform, measuring not over 0.3 mm. in breadth and 3 mm. in length, others (such as those of figs. 4 and 5) in a moderately contracted state are nearly 12 mm. long and $2\frac{1}{2}$ mm. broad. The latter, when fully extended, would probably double in length but diminish considerably in breadth.

To illustrate the various shapes presented by the worms I have given in figs. 2-15 a selection of specimens, all killed with sublimate solution while living and moving in a watch-glass. In some specimens the body is distinctly flattened, without doubt in the dorso-ventral direction (figs. 4 and 5). In other cases this is not so apparent or is even scarcely perceptible; but then the body in transverse sections generally presents a more or less oval outline (figs. 16 and 17). There exists no clue whatever to decide which of the flattened sides is dorsal and which ventral.

The shape of the worm in the simplest case is that of a typical Plerocercoid (fig. 2 *a-c*; figs. 3 and 13). It is simply thread-like in the fully outstretched state or may consist, in a moderately extended state, of the narrow, highly retractile head-end and of the broader hind region, or when strongly contracted may be of an irregularly cylindrical form, transversely folded on

the sides and broad at both ends which show each a depression due to invagination of terminal parts (figs. 2*d*, 9, 12). When the head is withdrawn to the utmost degree it may be difficult to distinguish that end from the hind end, and moreover it may happen that such a worm is but a fragment constricted off from the hind parts of the Plerocercoid and is thus devoid of the parts which may be called the head.

The simple Plerocercoid I regard as the original form of the larva, which, as will soon be shown, may acquire a widely different shape in a later larval stage. I regard it also as the form the larva would be in just before it begins strobilation after introduction into the final host.

Now a remarkable fact about the present Plerocercoid is that it is capable, at a certain advanced stage of its intracapsular life, of proliferating by a process of budding coupled with the before mentioned division of the body. We seem to have here to do with a process of which counterparts are known in the well known *Echinococcus* and *Cœnurus* as well as in *Cysticercus longicollis* and certain Cysticercoids, but which presents some peculiar features standing probably in connection with the Plerocercoid form of the proliferating larva. So far as my knowledge goes, a budding Plerocercus or Plerocercoid seems not to have been known before, at least not with certainty.

Among a large number of the specimens freed from capsules, those bearing from one to several buds or supernumerary heads in addition to the original terminal head of the simple Plerocercoid, are of quite common occurrence. The buds are found only on the larger-bodied specimens and therefore on those taken from the larger capsules. This shows that the budding takes place only after the Plerocercoid has grown to a certain size.

Facts observed warrant the statement that the worms in the early period of encystment, and therefore when still small and solitarily confined in the cyst, are simple Plerocercoids with the terminal head only. The budding may occur in any region of the broad posterior parts, but not on the narrow retractile head.

The specimens of figs. 4, 6 and 14 bear each a bud in different states of contraction and looking much like a lateral branch. The specimen of fig. 5 is in possession of two unmistakeable supernumerary heads; in this specimen, as also in that of fig. 4, the buds are situated plainly on lateral edges of the flattened body. This situation of the buds may in fact be the rule in the earlier period of proliferation; but as they increase in number and the mother-body assumes an irregular shape, the rule loses applicability in that they then appear to arise from quite indefinite parts of the external surface. Of specimens with numerous buds I have represented two in figs. 7 and 8. The original of the latter figure bore considerably over a dozen thread-like buds.

The structures referred to above as buds, differ in no way, except in situation and perhaps also in size, from the original, terminally situated Plerocercoid head. They manifest exactly the same shape and movements as the latter. The numerous buds in the specimens of figs. 7 and 8, at the time of killing, were almost all in vermiform motion while the mother-piece showed little or no movement. I think there can be no doubt whatever that the buds are to be looked at in the light of heads, secondarily produced but quite equivalent to the single terminal head. In the end it is quite immaterial to distinguish this original head from those formed later by budding.

Since now the larva is capable of transverse fission, it follows that the heads, irrespective of the manner of their origin, may

separate off from that body part with which they were originally continuous and may thus represent in themselves new independent individuals of the typical, though at first comparatively small, Plerocercoid shape. In this way can be explained the origin of the two or more Plerocercoids, occasionally found together in the same capsule.

Division alone or in combination with budding gives rise to various shapes of the worm-pieces which in various combinations may occur together in the same sapsule. To give a few illustrations from a number of cases observed :

On several occasions a typical Plerocercoid with head was found together with a plump, nearly cylindrical and headless piece or with two such pieces (like fig. 9 or 12). All the two or three pieces must have been derived by division from an original Plerocercoid that at first singly occupied the capsule. In these cases the division of body had evidently taken place before the worm had commenced budding.

From a large cyst were once obtained : a Plerocercoid with a supernumerary head on one side and looking very much like fig. 4 and two nearly barrel-shaped headless pieces (like fig. 12), both of which must have originally been continuous with the hind end of the first.

Another large cyst gave two small Plerocercoids of typical appearance and a large apparently headless body (like fig. 9). One of the former I take to be original Plerocercoid head and the other, an individual which has been budded off.

The specimen of fig. 5, bearing two buds and showing a strong constriction in the middle, was the sole occupant of a cyst. Should that constriction give way, what the result would be needs no explicit mention.

Of the seven specimens shown in fig. 2, all from a single cyst, three (perhaps four, *a-d*) are simple-shaped Plerocercoids, while three others (*e-g*) are quite irregularly shaped pieces bearing each a number of budded heads. All these worms, in my opinion, must have arisen out of a single original Plerocercoid after its encystment.

Not infrequently the more plump-bodied specimens show on the surface rounded wart-like or papilla-like tubercles which are quite distinct from the buds (figs. 2*f*, 7, 8, 10, 11, 15). Their formation is due, partly at least, to the accumulation in the parenchyma of a peculiar reserve nutritive matter which will be described further on. The external tubercles, conjointly with the buds, greatly contribute towards giving the worm a remarkable irregular shape (figs. 7, 8), which is sometimes met with, especially among the plump and many-headed—therefore assumably old—pieces of the worm.

Here a word about the headless and budless pieces (like fig. 12) that are segmented off from the hind parts of the Plerocercoid within the capsule. They are probably not in all cases to be considered as parts thrown off in the manner for example of, the caudal appendage of *Cysticercus*. Presumably they are still capable of producing buds. At any rate, there is no reason whatever to think that the budding can take place only while the original terminal head is present and not after this is lost by fission. Whether at the end of the proliferation the entire mother-piece would be used up in that process or whether there would finally remain a residue comparable to the vesicular appendage of a *Cysticercus*, and whether or not the Plerocercoid sheds off the posterior parts before it begins strobilation in the

final host, are related questions on which my observations offer no clue to a solution.

The head-buds in the Plerocercoid were observed in various sizes, but I have not been able to trace them back with certainty to the earliest stage of their formation. Perhaps from an early period they are capable of active movements, now everting and then inverting, so that the little rudiment, when fixed, may take the form of an elevation or depression, which on sections might not be easily distinguishable from mere irregularities of the surface. An accumulation of parenchyma cells, such as might possibly occur at the spot where a bud is to arise, has not come under observation.

The enormous numbers in which the parasite occurred in the patient is explained, in large measure, by proliferation taking place in the host. A young and small Plerocercoid, after separation from the mother-body which produced it, may be assumed to find its way out of the capsular wall. That act has not been actually observed but seems to really take place from the fact before mentioned that a number of the smaller sized Plerocercoids were found free in the connective tissue. It is not to be doubted that these free worms are to a certain extent capable of wandering through the tissues by virtue of the power of movements with which they are endowed. Probably however the wandering ceases after the worm has grown to a certain size and then it would begin to give stimulus to the surrounding connective tissue to form the capsule around it. This stands entirely in harmony with the account of the patient that from time to time new acne-like elevations made their appearance on the skin.

Some Points in the Structure of the Plerocercoid.—

The cuticula, sometimes 8μ thick but usually much thinner, presents a homogeneous or finely granular appearance. In contact with it is the delicate dermal musculature which as usual consists of the external ring and the internal longitudinal fibers. As regards the subcuticula and the general parenchyma there seem to exist no points deserving special notice.

The calcareous bodies (*cal.*, figs. 17, 21, etc.), spherical or ellipsoidal in shape and measuring $7\frac{1}{2}$ — 12μ across, are abundantly present in all parts of the parenchyma except in the anterior body-parts. The head-end is always found to be free of them. (In fig. 19 the numerous black dots stand for the calcareous bodies.) Especially numerous are they in the bulky parts of the larger specimens. It may happen that very small Plerocercoids, such as seem to have been recently budded off, contain only quite a limited number of them in the hind parts. In stained sections the bodies appear sometimes pale and homogeneous, but more generally exhibit the usual concentric lamination; they are either stained or unstained.

Quite remarkable is the occurrence, in the parenchyma, of peculiar fat-like or yolk-sphere-like bodies of various sizes (*r. n.*, figs. 17, 19, 20, 22). They occur isolatedly or several together in groups, without regularity as to their number and position in the body. Sometimes they are numerous present and are often of a considerable size, forming conspicuous objects when the worms are observed under the microscope and giving the impression that they represent some internal organs (fig. 19). As a rule they are constantly found in a greater or less number in the

broad hind parts of the older specimens. Especially abundant are they in those irregularly shaped, independent pieces which bear a number of head-buds. The head or the anterior parts of the worm are generally devoid of the bodies in question; but this is not always the case, as sometimes a limited number of the bodies occur even as far as a position close to the tip of the head. A few cases in which a small group of them was situated at the head-end misled me for a time into thinking that I probably had suckers before me. Small and young Plerocercoids, evidently recently detached from the mother-body, mostly showed no trace at all of the bodies under consideration. In all probability they are something which develops and grows both in size and number as the worm gets older and which, I may add, begins to undergo a disintegrating process after a certain period of existence.

In an early stage of development the bodies are small, spherical or irregular-shaped masses appearing very much like yolk-granules,—homogeneous, refractive and strongly stainable. The circumstances of their occurrence and the shape of the larger ones were often such as suggested the formation of these by coalescence of several smaller ones. The bodies may grow to a size of $150\ \mu$ or more in diameter, retaining the original compact appearance, though in sections they usually appear more or less broken into irregular fragments separated by narrow fissures. As yet they seem to be imbedded directly in the parenchyma, exhibiting neither a vacant space around them nor a special enveloping membrane. As already mentioned, the same bodies after growing to a certain size begin to show signs of dissolution in that they, beginning at the periphery, break up into finer or coarser granules as well as into conglomerate-like spherules that appear much like the white yolk-spheres of a hen's egg. Thus, the body may now

be, as it frequently is, represented by an unevenly granular substance inclosing a compact core of varying size, which core is the remnant of the original body in an unchanged condition. In a more advanced stage of disintegration the core disappears altogether and the body is entirely changed into a conglomerate-like mass consisting of granules and spherules of various sizes (*r. n.*, figs. 17, 20, 22). This change in character of the body is accompanied by a considerable increase in bulk. Moreover, after the setting in of the disintegrating process, the mass comes to lie in a vesicular space which is delimited from the parenchyma by a sharply defined, structureless membrane. The vesicle is generally roundish or oval, measuring 100–300 μ in diameter; occasionally it is found drawn out into a canalar shape of considerable length (as on the left of fig. 20). The bounding wall is at first thin but later so increases in thickness that it comes to resemble in a remarkable degree the cuticula of the worm. Now and then I have noticed on its inner surface fine hair-like processes, but this appearance I am inclined to regard as having been caused by a part of the contents sticking to that surface. The conglomerate-like mass either entirely fills up the internal space or leaves between it and the wall a peripheral space, which in sections is quite clear but may sometimes show traces of a very finely granular and faintly stained coagulum.

As to the significance of the body or substance described above, the most likely explanation seems to be that it represents a nutritive matter held in reserve, physiologically comparable to the fat of higher animals or to the amyllum in plants. The storing up of the matter probably stands in relation with the high proliferating power possessed by the present worm. The reactions towards reagents indicate that the substance is not ex-

actly a fat but more probably an albuminoid. Similar, if not identical, bodies are known from certain other larval Cestodes. AUBERT¹⁾ found in *Gryporchynchus pusillus*, a Plerocercus from *Tinca vulgaris*, a large number of refractive spherules massed together in the hind body; they were held by the describer to be fat, but this seems to require confirmation. The peculiar "Schollen," described by BARTELS²⁾ from the hind parts of *Cysticercus fasciolaris*, seem to closely agree with the bodies I have met with in *Plerocercoides prolifer*. In this relation might further be mentioned the clear drop-like spheres which are known to appear in *Cysticercus pisiformis*, etc. at the place occupied later by the internal cavity of the caudal appendage. This may be held to be an indication that there possibly may obtain a genetic relation between that cavity and the vesicular spaces containing reserve nutritive-matter in *Plerocercoides prolifer*.

An extensive system of excretory vessels traverses the entire body of the worm (*ex.*, figs. 16, 17, etc.). As in the Bothriocephalidæ generally, there exist several main vessels running in an approximately longitudinal direction. These frequently branch and anastomose with one another, thus bringing about an irregular network of the vessels. Those of largest caliber are seen in the posterior parts of the body, where they may be of a considerable width. As in *Bothriocephalus mansoni*, transverse sections through that region show them in section numerous in all parts of the parenchyma except in the peripheral zone (fig. 17). The external opening at the hind end could never be distinctly brought into view. Towards the anterior parts the network of

1) H. AUBERT. Zeitschr. f. wiss. Zool. Bd. 8. P. 284.

2) E. BARTELS. Zool. Jahrb. Abth. f. Anat. u. Ont. Bd. 16. P. 516.

the larger vessels divides into two, more or less clearly distinguishable lateral tracts, each of which, further anteriorly in the head, runs out into a single main canal on both sides. I have no observation on the capillary vessels.

On several occasions I have seen parts of the excretory vessels excessively swollen for a longer or shorter extent, apparently the result of an unnatural stowing of the fluid contents. In fig. 18 is shown the head of an individual with an abnormally swollen vessel, which at the extreme tip formed a loop and was continuous with another of much smaller caliber. I have been unable to exactly decide whether the vessels referred to were the two lateral vessels communicating with each other at the anterior end, or whether they represented ascending and descending parts of a lateral vessel of one side. Frequently, as the worms were observed under pressure between glasses, the swollen parts of the excretory vessels were seen to be filled with granules, apparently those of the reserve nutritive-matter that must have found its way into the vessels by rupture of tissues at some point.

Of the parenchymal musculature there exists in the first place a well developed system of longitudinal muscles, to the action of which should be ascribed the contractility of the body in length and the great retractility of the head. In them the fibers form anastomosing bundles, running from the tip of the head to the caudal end and present in all parts of the parenchyma except in the periphery (figs. 16, 17, 21, 22). The bundles are strongest and most numerous in the thick hind parts of the body. Where a head bud arises from the mother-body they give off branches into it as do also the excretory vessels.

Another, much less strongly developed system of the parenchymal musculature consists of fine muscular fibers which run singly, leaving wide spaces between, in various directions but mainly in the transverse plane of the body. In the narrow anterior parts (the head), as seen on cross-sections (fig. 16), there is observable a tolerable regularity in the arrangement of the fibers in that a set of them runs in an approximately transverse direction while another takes a dorso-ventral course. In the thick posterior parts (fig. 17), all the fibers run in quite an irregular manner, which fact is probably largely due to the crowded occurrence, in this region, of the wide excretory vessels and of the longitudinal muscular bundles. Transverse muscles in a continuous layer, dividing the parenchyma into cortical and medullary zones, do not exist.

With respect to the nervous system, all that I have seen is limited to the following facts. A pair of nerve trunks (*n.*, fig. 16) run in the usual position; they were observed with distinctness only in the anterior parts of the body. They seemed to unite at a position close to the tip of head. In the thick posterior parts of the body, they were not at all distinguishable.

Taken all in all, *Plerocercoides prolifer* shows a far-reaching structural agreement, especially in the musculature and the excretory system, with the Bothriocephalid larva *Sparganum* of DIESING, as well as with COBBOLD'S *Ligula mansonii* so-called, which was provisionally referred to *Bothriocephalus* by LEUCKART. Indeed, it may be admitted to be nearly certain that the worm

is one of the Bothriocephalidæ, notwithstanding the fact that the head is found to be without bothria. Perhaps it is assumable that a definite suckorial organ or organs might yet develop at a later developmental stage of the worm than those I have had for observation. Equally possible it seems, on the other hand, that the head keeps up the observed simple condition even to the mature stage,—that we have here to do with a Bothriocephalid which has lost all trace of bothria. Perhaps these are wanting in the so-called *Ligula mansoni* also; at any rate they have never yet been seen with certainty in that larval Cestode. Accordingly it may possibly turn out that “*Ligula mansoni*” and *Plerocercoides prolifer* represent very nearly related forms, perhaps generically identical. A more exact systematic determination of the larval forms can not be made with certainty until they have been traced up to the sexually mature stage.

I consider it futile to enter here into speculations concerning the past and future life-history of the larval Cestode described in this paper. Great interest is of course attached to feeding certain animals (*e. g.*, cats, dogs, or pigs) with the larvæ for the purpose of raising the mature worm, and also to determining if they can be operatively transplanted into the connective tissue of animals and there made to proliferate. Experiments in these directions I have caused to be made by Professor KONDŌ's assistants, but unfortunately they have borne no fruit. As the patient's return to the hospital is held in prospect, I am in hope of obtaining a new supply of the material with which to renew the experiments.



PLATE.

Explanation of figures.

Plerocercoides prolifer.

- Fig. 1. A vertical slice of the skin and subdermal tissues taken from the left thigh of the patient, showing numerous encysted *Plerocercoides prolifer* in situ. Hardened in alcohol. Above, the epidermis. From some of the cysts the worm had fallen out. Natural size.
- Fig. 2 *a-g*. Seven separate pieces of the worm taken from a single large cyst. Magnified $1\frac{1}{2}$ times. Photographed after fixing with corrosive sublimate. *a-c*, simple Plerocercoids. *d*, a strongly constricted piece of the worm (with involuted head?). *e-g*, irregularly shaped pieces budding out heads.
- Figs. 3-15. Worms in various shapes; all drawn from fixed specimens, magnified 4 times.
- Fig. 3. A specimen of simple Plerocercoid shape, with the extreme head-end invaginated.
- Fig. 4. Plerocercoid bearing a branch-like supernumerary head on one side.
- Fig. 5. A similar specimen, bearing two supernumerary heads and strongly constricted in the middle.
- Fig. 6. A specimen with a branch-like bud; the terminal head, either not present or strongly withdrawn.
- Figs. 7 and 8. Irregular-shaped specimens with numerous heads formed by budding.
- Figs. 9 and 10. Contracted specimens, either without the head or with the same strongly withdrawn.
- Fig. 11. A specimen, irregularly coiled and with tubercle-like protuberances.
- Fig. 12. A piece constricted off from the hind parts of a Plerocercoid. Invaginated at both ends.
- Fig. 13. A Plerocercoid greatly stretched out, but with the extreme head-end still retracted.

- Fig. 14. A Plerocercoid with the terminal head either lost or strongly retracted, but with a greatly outstretched head-bud.
- Fig. 15. A Plerocercoid moderately stretched out and with irregularities of contour in the anterior parts.
- Fig. 16. Cross-section through the anterior part (head region) of a Plerocercoid. Magnified 100 times. *n.*, lateral nerves. *ex.*, excretory vessels in section. The black dots represent partly nuclei and partly longitudinal muscular fibers in section.
- Fig. 17. Cross-section through the posterior part of a Plerocercoid. Magnified 100 times. *cal.*, calcareous bodies. *ex.*, excretory vessels. *mus.*, bundles of longitudinal muscular fibers, which, in many other parts, are represented by the larger black dots. *r. n.*, reserve nutritive-matter in capsule.
- Fig. 18. Head-end of a Plerocercoid fully stretched out, showing the simply rounded tip. Drawn from a specimen clarified with glycerine, 30 times magnified. Excretory vessel in part strongly swollen on account of the stowing of the liquid contents.
- Fig. 19. A Plerocercoid pressed under glass; over-stained with carmine and afterwards bleached with caustic potash. Black dots represent well-stained calcareous bodies, which are absent in the head region. Reserve nutritive-matter (*r. n.*) in the form of numerous balls. A pair of excretory vessels (*ex.*) in the anterior parts. Magnified 30 times.
- Fig. 20. A section through an irregular-shaped piece bearing a number of buds or heads, parts of which are seen in two places (*h.*). Other lettering as in fig. 17. Magnified 50 times.
- Fig. 21. A horizontal section through the nearly fully evaginated head-end of a Plerocercoid. Lettering as in fig. 17. Magnified 50 times.
- Fig. 22. A horizontal section through the hind parts of a Plerocercoid. Lettering as in fig. 17. Magnified 50 times.
- Fig. 23. Section of a worm-cyst lying in the subdermal connective tissue. About 8 times magnified.
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Mesozoic Plants from Korea.

By

H. Yabe, *Rigakushi*.

University Hall, Imperial University of Tokyo.

With 4 Plates.

Introduction.

Palaeontologically speaking, Korea¹⁾ is the least known of all the countries of Eastern Asia. The first notice on Korean fossils is found in GOTTSCHE's "Geologische Skizze von Korea", in which he mentions the occurrence of a Cambrian fauna in a limestone

1) Having arrived at Chemulpo (Inchhyön), Korea, in the end of August, 1903, the present writer was engaged in field work for about two months up to the beginning of November, when he took his way home from Fusan (Pusan). During the month of September, he made a journey along one of the main roads from Seoul to Fusan, through Tyo-ryöng on the boundary of northern Kyöng-syang-Do and Chhung-chhyöng-Do, in order to obtain a general knowledge of the various geological formations in which there was probability of the occurrence of organic remains, and especially to make a collection of the Palaeozoic plant fossils at a locality close to Mun-gyöng, known since GOTTSCHE's exploration. From the 3rd to the 15th of October, he made a second tour from Fusan to Yöng-il along the eastern coast, making there a collection of plant fossils in the younger deposit of the said district. The existence of a plant deposit of a very recent age in this district was one of the important discoveries of Prof. KORÖ. During the remaining days, the writer was able to traverse Chyol-la-Do, starting from Mok-pho, by the way of Chyang-syöng, Chin-an; thence he crossed Yuk-sim-nyöng, and traversed Kyöng-syang-Do for the third time, passing near An-eni and through Chin-jyn, Sa-chhyön, Chin-hai and Masampho.

The palaeontological collections made during his first two months stay in the peninsula comprise:—

- I) Plant fossils of the Palaeozoic (?) from a locality near Mun-gyöng.
- II) Plant fossils of a middle or upper Mesozoic age from Naktoug.
- III) Plant fossils of a younger Tertiary age (?) from Yöng-il.

found near Chho-san and Ui-uön, northern Phyöng-ang-Do, and of plant impressions in a slate exposed near Mun-gyöng, northern Kyöng-syang-Do.

He also mentions indeterminable plant remains as occurring in the slates of Naktong, Northern Kyöng-syang-Do, which are said to lie unconformably upon gneiss, and to gradually pass above to a thick complex of sandstones and shales. This formation was provisionally taken by him as synchronous with the plant-bearing slate of Mun-gyöng, above alluded to, which he believed to be of the Carboniferous age from the presence of a species of *Neuropteris* which he compared to *N. flexuosa* STERNB. But Professor Kotō who has recently made extensive travels in Korea considers these two plant-bearing rocks as belonging to two distinct geological horizons, for the younger of which he proposes the name “Kyöng-syang Formation.”

The second tour in the southern part of the peninsula was made in September and October of 1904, for the purpose of tracing the extension of the Mesozoic deposits in the southwestern portion of Chyol-la-Do including Na-jyu and Nam-nön, and in a narrow belt of land stretching northeastward from the said district to the southeastern corner of Chhung-chhyöng-Do, where he had previously no opportunity of observation. Consequently, this time, he traversed the Chyol-la-Do by the way of Mokpho, Yong-am, Nam-phyöng, Koang-jyu, Tong-pok, Ok-koa, Nam-nön, Im-sil, Chyön-jyu, Chin-an, Yong-dam, Keum-san and Mu-jyu, and then entering the Chhung-chhyöng-Do went as far as the Keifu-railway line, then in the process of construction, at Yong-dong. Thence he made a visit to Ok-chhyön on the west and to Hoang-gan on the east, and then went to Syang-jyu, Ilam-chhyang, Po-eun and Chhyöng-san, returning to Hoang-gan after a week. In this way, the Syong-nisan ridge was crossed between Ham-chhyang and Po-eun from east to west. Afterward he went along the railway southeastward by Chhyu-phung-nyöng, Keum-chhyön and Pu-sang, to Tol-pa. Next a few days were spent in making a research along both sides of the Nak-tong-gang between Tol-pa on the south and Nak-tong village on the north, and then going from Tol-pa to Fusan by railway, the journey came to the end.

Paleontologically, no important results were obtained from this second journey of about 50 days. Only in the Mesozoic deposits of Yong-dong and its vicinity, a few plant remains of an almost indeterminable preservation and consequently of very little or no value, were obtained in a slaty rock harder, though geologically a little younger, than the shales of the Nak-tong plant beds. From the latter, on the contrary, he got 4 or 5 additional species, not found in the collection of the preceding year.

The development of this Kyöng-syang formation is principally found in a rectangular area bounded on the east and south by the coasts of Kyöng-syang-Do, on the west by the meridian of 128° and on the north by a line roughly coinciding with latitude $36^{\circ} 30'$. The region covers the main portion of the well populated Kyöng-syang-Do, with exclusions of numerous small areas composed of Tertiary and younger sediments, and also of eruptives.

There is another area in which this formation is found, but it is less extensive, lying in southern Chyol-la-Do. Like the other it is almost quadrate in outline, being bounded by the lines connecting Mokpho, Ok-koa, Ku-ryoi and Hai-nam successively, and is composed of two topographically well marked portions, the low, well cultivated southwestern plain and the more or less wooded northeastern highland.

Connecting these two separate areas, there runs a narrow belt of the same sediments, from northeast to southwest for about 200 km. through Chyol-la-Do. From Mokpho in the southwest, it runs through Chyang-syong and then north of Im-sil, west and north of Chin-an and near Mu-jyu where it disappears for a short distance in a region consisting of gneisses and biotite-schists. But it reappears at the southwest of Yong-dong in Chhung-chhyöng-Do which lies due north of Hoang-gan. It is again intercepted by the gneiss plain of Syang-jyu for a distance of about 20 km. In general, the belt has a width of about 16 km. along the road between Ok-chhyön and Hoang-gan, and between Im-sil and Chyöng-jyu.

East of Chhyön-san, in Chhyung-chhyöng-Do, there is also an isolated area composed of the same rocks, but its exact extent is at present not definitely known.

In this formation, GOTTSCHÉ distinguished five series of rocks which enumerated from below are as follows :

1) Dark marly shale, alternating with a fine grained, fragile sandstone.

2) Bituminous clay, partly discoloured, with small coaly flecks and obscure vegetable impressions.

3) Conglomerate, arcose near the base, with numerous, very compact layers of the same rock.

4) Marl of various grades of colour between violet and chocolate-brown, with frequent intercalations of compact limestones.

5) Thick banded sandstone, conglomerate-like near the base.

The total thickness of these series of rocks is estimated by GOTTSCHÉ as more than 600 m., i.e. 25 m. for the first ; 15 m. for the second ; 450 m. for the third ; 70 m. for the fourth ; and 40 m. for the last series.

According to the writer's view, the Kyōng-syang formation is a much thicker complex, with frequent intercalations of red tuffs and porphyrite sheets in the upper portion. The study of many local profiles led him to recognize by means of the predominating rocks the following four principal divisions of the formation. The uppermost part is characterised by porphyrite sheets and a green breccia associated with them. The next part contains thick layers of several kinds of red coloured tuffs partly brecciated, together with a greenish slaty rock. The third part is mainly composed of a hard sandstone, often passing into a conglomerate and usually underlaid by a thin shale, a red tuff and an amygdaloidal sheet. The fourth part is composed of a series of thick slates, green or black in colour and often sandy,

containing a few plant remains, mostly indeterminable. Below these four parts, there is a thick conglomerate gradually passing below into a sandstone with intercalations of shales which are sometimes coaly.

As to the distribution of these parts in Kyöng-syang-Do, the uppermost shows a wide extent around Fusan, while the lowest appears along the boundary of the Mesozoic area against granite and gnesis in the west; the other two parts occur in areas between these two, although their distribution has in many cases become complicated by dislocations.

The upper conglomerate, No. 5 of GOTTSCHÉ, is distinguished from the lower usually by the occurrence of a red tuff and amygdaloidal rock sheet below it and also by being covered by a thick series of a red tuff above. A similar rock series also forms an extensive area in southern Chyol-la-Do and in the narrow belt between Chang-syöng and Yong-dong. In the latter, it is underlaid by thick greenish and black slates. GOTTSCHÉ differs from the writer in considering this conglomerate exposed near Chin-an as the equivalent of a similar rock which he calls No. 3 in his Nak-tong section, and consequently in taking the underlying complex as corresponding to No. 2 and No. 1. But the writer, from his own observation, is inclined to consider the conglomerate as representing the upper horizon, i. e. No. 5 of GOTTSCHÉ, while the lower series probably corresponds to his No. 4.

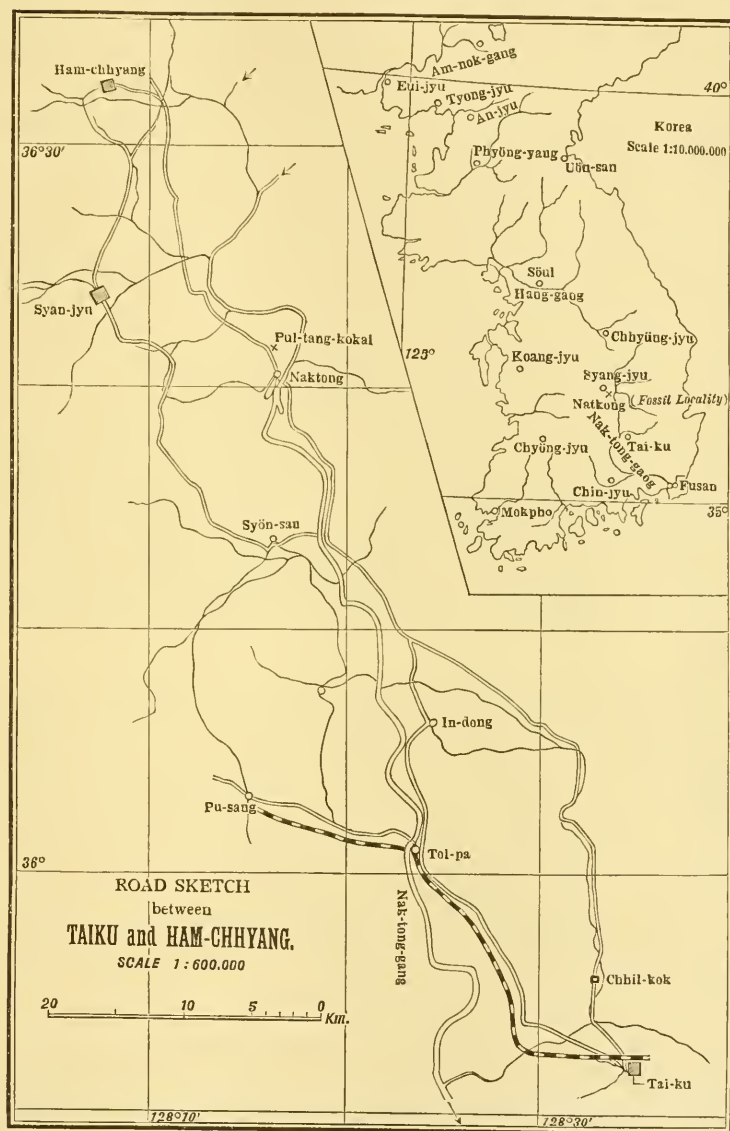
According to the writer's opinion, the lowest part of the Kyöng-syang formation is to be distinguished from the rest, under the name of the Naktong series. It seems exactly to correspond to the divisions, No. 1, No. 2, and No. 3, of GOTTSCHÉ. It is characterized by loose sandstones and inter-

calated seams of a coaly shale as above stated. In thickness, it is far inferior to the remaining upper portion of the Kyöng-syang formation. Its peculiarity consists in the easy destructibility of its shales and sandstones by atomospheric agencies; the hills in the region of these rocks are usually very low and undulating, except where capped with a thick conglomerate bed when they are high and steep. The scarcity of vegetation and the low mound like hills give the landscape a peculiar aspect. The upper portion of the Kyöng-syang formation is generally composed of harder rocks, also with frequent intercalations of conglomerate and breccia, especially near the top. The topography of the region is tolerably distinct from that described above; it consists of mountains or hills of higher elevations and where the water courses have cut into these rocks, perpendicular bluffs are presented which afford excellent opportunities for the study of the order of rock layers, and for searching for fossils, although few of the latter have been obtained and those only from the lower series in a very bad state of preservation. Ripple-marks have frequently been met with in the rocks of the upper series.

A greater regularity prevails in the arrangement of the rock-layers of the Kyöng-syang formation. They seem not to have suffered from any great subsequent disturbances except by the faulting of the Korean and Hansan systems, therefore they retain nearly their original horizontal position, dipping very slightly to the east (strictly speaking, the dip varies locally from NE. to SE.).

The collection of fossils to the description of which this paper is solely devoted, was made on a slope of a hill named Pul-tang-kokai, on the way from Söul to Fusan, and at about

4 km., northwest of a village called Naktong which is situated close to the river of the same name. Here the rock of the



Naktong series is typically developed. Numerous seams of coaly shale, seldom over half a meter in thickness, are found exposed

along the road; they are intercalated in a complex consisting of alternations of shales and sandstones, the latter of which often pass into a conglomerate, which is underlaid by marly shales and hard sandstones. Some of these underlying sandstones are coarse grained, and in one of them was found a large impression of a fern frond, which, however, is too badly preserved for determination. Marl nodules, rarely with Foraminifera, are found in the sandstones. In the coaly shales themselves and in the intercalated shales, vegetable remains are everywhere found, but either as indistinct impressions or as small fragments; among the former we find sometimes crowded impressions of *Nilssonia*, and in one of the latter abundant fragments of *Onychiopsis* were also observed. A locality for better preserved plants is in a valley at the eastern flank of the hill above alluded to, where a shale of a dark brown colour is very rich in fossils. This locality promises to yield an abundant harvest to future collectors.

The fossil flora, so far as the number of species is concerned, must be called a poor one, although some of the species are rich in individuals. It contains certain forms by means of which it is possible to determine with approximate accuracy the age of the strata in which they occur. There is no doubt that the flora is of the middle Mesozoic age;¹⁾ it is therefore of considerable value, not only for the determination of the probable age of the

1) Once, Mr. Y. ISHII suspected that the coal-bearing deposit near Ph्यों-gang belonged to the Cretaceous age, though, as he said, there was neither paleontological nor stratigraphical data for confirming such an opinion. More lately, BRUNO KNOCHENHAUER has said "Kretacische Gebilde treten nur inselförmig an der Ostküste auf" (Korea, p. 111, 1909); but how he came to speak of the Cretaceous deposits, it is not known.

E. v. AMNERT also reported the occurrence of a Jurassic coal-bearing deposit in an area along the middle course of the Tu-man-gang and its left branch the Bolohotung (布爾哈圖).

upper Kyöng-syang formation and hence of the dislocation of the Korean and Hansan systems, but also of the geographical distribution of the middle Mesozoic flora.

The study of the flora, above alluded to, was first suggested to the writer by Prof. B. KOTŌ, by whose encouragement the writer had the opportunity to twice visit the territory under discussion. It was first intended that this note should be included in the more comprehensive work on Korean geology by this professor; but by kind permission, it is now given an earlier publication.

The writer is also indebted to Prof. M. YOKOYAMA for assistance in regard to palæontological points and for a painstaking revision of his manuscript.

Acknowledgment is also due to Prof. K. MITSUKURI, Director of the Science College, and to Prof. I. IJIMA, of the publication committee of the Journal.

DESCRIPTIONS.

CYCADOPHYTA NATHORST.

DICTYOZAMITES OLDHAM.

T. OLDHAM¹⁾ speaks of the genus *Dictyozamites* as “very interesting as a fossil plant, but of no importance in the determina-

1) T. OLDHAM and J. MORRIS: Fossil Flora of the Rajamahal Series in the Rajamahal Hills. 1863.

tion of the age of the flora ; only characteristic of the Rajmahal group ” ; but the subsequent discovery of the genus in the fossil flora of many other lands has led A. C. SEWARD¹⁾ lately to make a short but interesting contribution on the history, time range, and distribution of the genus, accompanied by an important article upon the plant geography of the Jurassic age. Indeed, it was by the occurrence of this plant in the Naktong flora that the present writer was able to draw the conclusion that the deposit is of the Mesozoic era and most probably of the Jurassic age.

The species of the genus hitherto known, according to SEWARD, number only three :—

1. *D. falcatus* OLDHAM.

Rajmahal series of the Rajmahal Hills, and upper Gondwana of the Madras coast, India.

2. *D. falcatus* OLDH. var. *distans* YOK.

Tetori series of Japan.

3. *D. falcatus* OLDH. var. *grossinervis* (YOK.)

Tetori series of Japan.

4. *D. Johnstrupi* NATH.

Liassic or Rhaetic bed of Bornholm.

5. *D. Hawelli* SEWARD.

Lower Estuarine of Marske, Yorkshire, England.

As is seen from the above enumeration, this genus is surely known from the Jurassic. In strata older or younger than the above, it has not yet been known to occur.

1) A. C. Seward : Occurrence of *Dictyozamites* in England, and on European and Eastern Mesozoic Floras. 1903.

DICTYOZAMITES FALCATUS (MORRIS).Pl. II., figs. 2-7.¹⁾

1863. *Dictyopteris falcata* and *D. falcata* var. *obtusifolia* OLDHAM and MORRIS: The Fossil Flora of the Rajmahal Series, Rajmahal Hills, Bengal. P. 38, pl. XXIV., figs. I, 2.
1876. *Dictyozamites indicus* FEISTMANTEL: Ueber die indischen cycadeen Gattungen *Ptilophyllum* MORRIS u. *Dictyozamites* OLDHAM. P. 18, pl. IV., figs. 7, 8; pl. V., figs. 1-4; pl. VI.
1877. *D. indicus* FEISTMANTEL: Jurassic Flora of the Rajmahal Group, in the Rajmahal Hills. P. 70, pl. XLVI., figs. 7, 8.
1877. *D. indicus* FEISTMANTEL: Jurassic Flora of the Rajmahal Group of Golapili. P. 180, pl. II., figs. 5, 6.
1879. *D. indicus* FEISTMANTEL: The Fossil Flora of the upper Gondwanas Outliers of the Madras Coast. P. 24, pls. III-V.; pl. XVI., figs. 4-7.
1889. *D. indicus* var. *distans* YOKOYAMA: Jurassic Plants from Kaga, Hida and Echizen. P. 53, pl. X., figs. 4-10; pl. XI., fig. 5.
1899. *D. grossinervis* YOKOYAMA: l. c. P. 55, pl. VII., fig. 10.
1903. *D. falcatus* SEWARD: Occurrence of *Dictyozamites* in England. P. 218, pl. XV., figs. 5-8.

1) All the specimens, figured in the accompanying plates, are in the Sci. Coll. Mus.

Frond pinnate; pinnae closely set in two alternating rows, attached to the upper surface of the rachis by the middle of the base at an angle of about 70° . Pinnae linear, very slightly falcate, gradually tapering to the bluntly pointed apex; ranging between 5.0×0.2 cm. and 1.2×0.3 cm. in size. End pinna smaller than others. Venation very distinct, showing numerous areoles. Areoles narrow, elongate and subquadrate, parallel to the margin in the middle of the pinnae becoming shorter and diverging gradually near the margin.

This most characteristic species is quite common.

The pinnate fronds obtained in Korea are a little broader than the Indian examples figured by OLDHAM and FEISTMANTEL, but the pinnae of the former are generally narrower than those of the latter. In other respects, there are no distinctions between them.

As in *D. falcatus* from India, our examples also vary greatly in the shape of the pinnae and the size of the areoles. Thus, the basal portion of the frond shown in fig. 2, is shorter and broader than in others. But there is no example in the writer's collection in which the pinnae show areoles so coarse as in some of the Indian and Japanese specimens. *D. grossinervis* of Prof. YOKOYAMA,¹⁾ distinguished by having a less number of coarser areoles, was reduced by SEWARD²⁾ to the rank of a variety of the latter. Probably the Korean examples might also better be treated as a particular variety.

Two fragments of detached pinnae drawn in the same plate (figs. 6, 7) show a somewhat different outline from the others, being considerably broader and more abruptly attenuated to the

1) YOKOYAMA: l. c. P. 55, pl. VII., fig. 10.

2) SEWARD: l. c. P. 3.

pointed apex. These are here also treated as belonging to the same species, although with doubt.

NILSSONIA BRONGN.

NILSSONIA ORIENTALIS HEER.

Pl. III., figs. 1-5.

1878. *Nilssonia orientalis* HEER: Beitr. zum Juraflora Ost-sibiriens u. d. Amurlandes. P. 18, pl. IV., figs. 5-9.

1889. *N. orientalis* YOKOYAMA: l. c. P. 41, pl. XIV., figs. 4-9.

1897. *N. efr. orientalis* NATHORST: Zur Mesoz. Flora Spitzbergens. P. 24, pl. I., figs. 18, 19.

Fronde longly oval, entire; truncated at the apex and attenuated gradually below. Veins fine, dense, 3-4 in the space of 1 mm.; slightly curved and directed forward, especially near the apex.

None of the fronds of *Nilssonia orientalis* from Siberia figured by HEER are complete. Yet, the Korean specimens show in general a great resemblance to them and also to the Japanese specimens described by Prof. YOKOYAMA. The only difference between the Korean and the Japanese specimens is that the base of the frond in the former is not so much rounded as in the latter. The writer, however, thinks it almost certain that both belong to one and the same species. Their resemblance to the

fronds mentioned by NATHORST as *N. cfr. orientalis* from Spitzbergen is also striking. *N. tenuinervis* NATH. from Yorkshire and Bornholm is no doubt an ally of this oriental species, as already pointed out by NATHORST, HEER and SEWARD. Very recently, NATHORST reported the occurrence of a *Nilssonia* very much like the European species in a Jurassic deposit at Esperance Bay, Louis-Philipp land.

NILSSONIA SP.

Pl. III., fig. 6.

The fragment here figured belongs to a species decidedly different from the preceding. It shows a lower portion of a leaf, which is cut into two alternate segments. The segments are continuous at the base; the upper margin is nearly straight, the lower strongly convex, and both make an acute angle between them. In this respect it closely resembles *N. nipponensis* YOK.¹⁾ from the Japanese Jurassic, but is distinguished from it by having very densely crowded veins (about 6 in a millimeter).

DIOONITES, BORNEM.

DIOONITES (?) SP.

Pl. III., fig. 7.

There is another fragment of a pinnate frond, 2.7 cm. in length, which appears to have been thin in texture. About

1) YOKOYAMA: l. c. p. 42, pl. VI., fig. 8d; pl. VII., figs. 2-7, 8a; pl. XLI., fig. 6.

eleven pinnae which are close together are preserved on one side of the rachis, meeting those of the other side along the median line of its upper surface; none of the pinnae are perfect; they vary in breadth from 1.5 to 2.5 mm. and are parallel sided, expanding a little near the base where they are slightly decurrent. The veins are fine, simple, and uniformly distant; 5-8 in a segment.

This fern is not unlike *Dioonites Kotōei* YOK., but its imperfect preservation renders a strict comparison impossible.

CTENOPHYLLUM, SCH.

CTENOPHYLLUM (?) SP.

Pl. IV., fig. 7.

A slab of shale with a splendid example of *Cladophlebis koraiensis* shows, besides, two fragmental impressions of pinnate cycadean fronds.

One of them bears about fourteen linear pinnae on one side of the rachis, and the other four; none of these pinnae are, however, perfect. The rachis is stout, about $1\frac{1}{2}$ mm. in breadth. The pinnae attenuate but little toward the broken apex; they are very close together and alternate; the mode of insertion cannot be satisfactorily made out, the rachis showing only the dorsal side. The veins are rather thick, 5-6 of them fork shortly after leaving the rachis. The longest pinnae, also imperfect at its apex, has a length of 1.2 cm. and a breadth of ca. 3 mm.

Only two fragments of this plant have been obtained, so that exact determination is at present impossible. Though not unlike *Dioonites Kotōei* in some respects, their generic distinction is obvious, for the Japanese species has simple veins while those from Korea usually fork once.

PODOZAMITES,¹⁾ FR. BRAUN emend. SCHENK.

PODOZAMITES REINII GEYLER.

Pl. IV., fig. 6.

1877. *Podozamites Reinii* GEYLER: Ueber Fossile Pflanzen aus der Juraformation Japans. Pp. 229–230, pl. XXXIII., fig. 4a; XXXIV., 1, 2, 3b, 4, 5a.

1899. *P. Reinii* YOKOYAMA: l. c. p. 50, pl. III., fig. 6a-c; IX., 12a; XII., 4.

Two detached pinnae of *Podozamites*, distinguished from the following species, by their ovate outline and more numerous veins, are to be identified with *P. Reinii* GEYLER, peculiar to, and abundant in, the Japanese Tetori series, first described in detail by GEYLER and then by Prof. YOKOYAMA. Hitherto it has not been known to occur outside of Japan; therefore it is to be looked upon as a species indicating a close relationship between the Tetori and the Naktong floras.

One of the specimens measures 2.0 cm. in breadth and has forty-two parallel veins with numerous fine interstitial ones.

1) This genus is here provisionally placed in Cycadophyta according to the customary acceptation, though its position is not certain.

PODOZAMITES LANCEOLATUS (LINDL. and HUTTON).

Pl. IV., figs. 1-5.

1877. *P. lanceolatus* GEYLER: l. c. P. 228, pl. XXXII., figs. 1, 4; XXXIII., 1-3, 4b; XXXIV., 3a, 5a.
1889. *P. lanceolatus* YOKOYAMA: l. c. P. 45, pl. IV., figs. 1a & c, 2, 3a, 4a-b; V., 1, 2b, 3, 4, 5a-d, 6, 7, 8, 9; VI., 1; VII., 8b; IX., 6; XII., 18; XIV., 12a.
1894. *P. lanceolatus* YOKOYAMA; Mesozoic Plants from Kozuke, Kii, Awa and Tosa. P. 222, pl. XIII., figs. 1, 3, 4, 5, 6, 8, 9; XIV., 1-3, 5.
1905. *P. lanceolatus* YOKOYAMA: Mesozoic Plants from Nagato and Bitchu. P. 6, pl. I., fig. 6; p. 13, pl. III., fig. 5.

For further references see SEWARD'S Jurassic Flora, p. 242.

This widely spread, well known species is also present, though rare, in the Naktong flora. The few specimens obtained are all detached pinnae, mostly imperfect either in their apical or basal portions, or in both. The poor state of their preservation and the rarity of their occurrence, in contrast with the richness and excellent preservation of the associated fern fronds, seem to indicate that they belong to that kind of vegetable remains which have been drifted from a great distance.

Some of the best preserved examples are given in the accompanying plates. Figure 2 represents a broad pinna lacking its apex, but with rapidly narrowing base pierced by about thirty veins in a space 1.9 cm. in breadth. It reminds one strongly of var. *latifolia* HR. Fig. 1 is distinguished by its more lanceolate outline, gradually tapering above. It is not unlike var. *inter-*

media HR., but the veins are much more crowded. Besides, there are many other oblong pinnae (figs. 3, 5), smaller in size and with 22–25 veins. One (fig. 4) is characterized by its rounded apex and gently tapering basal portion and only 20 veins, the breadth of the pinna being about 1 cm. Therefore it may better be compared with *P. pulchellus* HR.¹⁾

CONIFERAE.

PINUS L.

PINUS SP.

Pl. II., figs. 9–10.

The existence of coniferous plants in the deposit of Naktong is shown by isolated linear leaves much like those of *Pinus Nordenskjoldi* and of its allied species described from the Jurassic deposits of Spitzbergen, Siberia, China, Japan etc. They are found uniformly scattered in the bed, though not numerically abundant. One can distinguish two types by their larger or smaller leaves. The larger leaves (fig. 9) usually attain 3 mm. in breadth and more than 4 cm. in length, with a midrib and numerous fine longitudinal striae on either side of it, thus being quite similar to *Pinus Nordenskjoldi* HR.²⁾ in every respect.

1) HEER: Beitr. zur Fossilen Flora Spitzbergens, p. 38, pl. IX., figs. 10–14. NATHORST: Zur Mesozoischen Flora Spitzbergens, p. 14, pl. I., figs. 6–11.

2) HEER: Beitr. z. Foss. Flora Spitzb., p. 45, pl. IX., figs. 1–6. Beitr. z. Juraflora Ostsib. u. d. Amurl., p. 76, pl. IV., fig. 8e; p. 117, pl. XXII., fig. 4a, b; XXVII., 4. Beitr. 1878, p. 26, pl. II., figs. 7–10. Nachtrag p. 28, pl. I., figs. 6b, 8c. YOKOYAMA: l. c. p. 63, pl. IX., fig. 12b.

Some bring *P. Nordenskjoldi* under the genus *Cyclopitys*, against which view Prof. YOKOYAMA¹⁾ has given a short argument in his description of the Japanese examples, citing the opinion of NATHORST. POTONIE also made a remark on *Cyclopitys*.²⁾ But in this place, it is sufficient to mention that the Korean example lacks the transverse wrinkles, though the longitudinal striae are quite distinct.

The smaller leaves (fig. 10) are about 1 mm. broad and more than 2 cm. long with a distinct midrib; there are no other particular characters to be mentioned. *Pinus* cfr. *prodromus* HR. from Japan³⁾ is at least a similar plant, if not specifically identical.

Though these two fossils are not of much value either from the chronological or the botanical point of view, yet they are at least worthy of consideration as representatives of the scanty remains of Coniferae in the deposit.

PTERIDOPHYTA.

FILICINAE.

LEPTOSPORANGIATAE.

POLYPODIACEAE.

ONYCHIOPSIS, YOK. 1890.

(Jour. Coll. Sci. Japan, vol. III., 1890, p. 26. Cat. Mes.
Pl. Dep. Geol. Brit. Mus. Wealden Flora I., p.
40, 1894.)

1) YOKOYAMA: l. c. p. 63.

2) POTONIE: Pflanzenreste aus der Juraformation. Futterer's Durch Asien III.

3) YOKOYAMA: l. c. p. 62, pl. XII., fig. 3.

The genus was first established by Prof. YOKOYAMA in 1890 for the reception of *Thyrsopteris elongata* GEYLER from the Japanese Jurassic, on account of the close resemblance of its fertile as well as sterile pinnae to those of the living species of *Onychium*. Immediately afterward, NATHORST¹⁾ pointed out the great similarity of VELONOWSKY'S figures of the fertile frond of *Thyrsopteris capsulifera* to the Japanese species, which fact led him to bring it under the same genus, and he further proposed to assign the well known European Wealden species—*Sphenopteris Mantelli* BRONGN.—to the same genus, which closely resembles *O. elongata*. This view was subsequently verified by SEWARD,²⁾ who examined fertile pinnae of *Sphenopteris Mantelli* from the British rocks and confirmed Prof. YOKOYAMA'S view, that the features of the fossil fern show a closer relationship to *Onychium* than to any other living genus.

SAPORTA³⁾ however on examining a fertile frond from Portugal was inclined to bring the position of *Sphenopteris Mantelli* under the genus *Davallia* or at least into the group of the *Davalliae*. But, SEWARD'S words⁴⁾ about this run as follows: "The comparison made by YOKOYAMA in the case of *Onychiopsis elongata* and by myself as regards *O. Mantelli*, with the recent genus *Onychium*, is, I believe, a much nearer approach to the truth than if we adopt the conclusions of SAPORTA."⁵⁾

The genus has a wide range from Jurassic through Wealden to Cenomanian; altogether 4 species being known at present.

1) NATHORST: Beiträge z. Mesozoischen Flora Japans. 1890.

2) SEWARD: Wealden Flora I. 1894. P. 43.

3) SAPORTA: Flora Fossile du Portugal. 1894.

4) SEWARD: Wealden Flora II., p. 229.

5) The fertile fronds of *Sphenopteris Mantelli* described by SAPORTA from the lower Cretaceous of Portugal appear to the writer somewhat different from those of the same species from Yorkshire and also of *Onychiopsis elongata*.

Of these four, *O. elongata* seems to have been abundant in the fossil floras of the Japanese Mesozoic. In the Tetori and Ryoseki series, a great many specimens are found from many localities, and the occurrence of the same in the somewhat older strata of Nagato has also been very recently pointed out by Prof. YOKOYAMA.

Another Japanese species—*O. elegans* YOK.—is known only by one specimen from the Ryoseki series of Tosa.

Outside of Japan, the genus also possesses a very wide geographical distribution. Particularly worldwide is the distribution of *O. Mantelli* which is a common fossil in the Wealden rocks of England, and also appears in the deposits of the corresponding age in Germany, Portugal, Austria and Belgium. Besides, the species is reported from the upper Jurassic of Portugal, though the identification of Saporta is doubted by SEWARD;¹⁾ otherwise it is an exclusively Wealden species. In North America, this species has been described from the Potomac formation of Virginia,²⁾ and in South Africa from the Uitenhage Series³⁾ of Cape Town. According to the recent publication of SEWARD,⁴⁾ *Trichomanites laxum* and *T. spinifolium* from Australia are mere synonyms of this species.

From the lower Cretaceous of Bohemia, another species is described under the name of *Thyrsopteris capsulifera*.⁵⁾ Besides, some of the specimens from England⁶⁾ and Bohemia⁷⁾ are referred

1) SEWARD: Wealden Flora II., p. 229.

2) Some of the numerous species of the genus *Thyrsopteris* described by FONTAINE from the Potomac of Virginia, are believed by SEWARD to be *O. Mantelli*.

3) SEWARD: Fossil Floras of Cape Colony, p. 5.

4) l. c.

5) VELENOWSKY: Die Farne der Böhmisches Kreideformation, p. 10, pl. I., figs. 6–12. KRASSER: Beiträge z. Kenntniss der fossilen Kreideflora von Kunststadt, p. 121. ANT. FRIC u. E. BAYER: Perucer Schichten, 1900, p. 44, fig. 12.

6) SEWARD: Wealden Flora, I., p. 55.

7) KRASSER: Beiträge, p. 121, pl. VII., fig. 1.

to *O. elongata*. All of these species closely resembling one another, it is sometimes questioned whether *O. elongata* is really distinct from *O. capsulifera* on the one hand or from *O. Mantelli* on the other. More recently, SEWARD¹⁾ has united *O. elongata* with *O. Mantelli*.

In short, *Onychiopsis* is a genus ranging from the Jurassic to the oldest part of the upper Cretaceous and is of a wide geographical distribution, and of the 4 species known, *O. elongata* seems to have the greatest chronological range.

ONYCHIOPSIS ELONGATA (GEYLER).

Pl. I., figs. 9-14; pl. III., fig. 15.

- 1871. *Sphenopteris Geopperti* SCHENK (in part): Palæontographica vol. XIX., pl. XXX., figs 2 and 2a.
- 1877. *Thyrsopteris elongata* GEYLER: Ueber Foss. Pflanzen a. d. Juraform. Japans. P. 224, pl. XXX., fig. 5; pl. XXVI., figs., 4 and 5.
- ? 1883. *Thyrsopteris elongata* SCHENK: Richthofen's China. Vol. IV., pt. X., p. 263, pl. LIV., fig. 1.
- 1886. *Dicksonia elongata* YOKOYAMA: On the Jurassic Plants of Kaga, Hida and Echizen. Bull. Geol. Soc. Japan. Pt. B. Vol. I., no. I., p. 6.
- ? 1889. *Thyrsopteris varinervis* FONTAINE: The Potomac or Younger Mesozoic Flora. P. 124, pl. XXVI., figs. 6, 7; pl. XLIII., figs. 4-6; pl. XLIV., figs. 1, 2 and 5; pl. XLIX., fig. 2; pl. CLXIX., figs. 6, 7.

1) SEWARD: Fossil Flora of Cape Colony, 1903, p. 5.

1890. *Onychiopsis elongata* YOKOYAMA : Jurassic Plants from Kaga, Hida and Echizen. P. 27, pl. II., figs. 1-3 ; pl. III., fig. 6d ; pl. XII., figs. 9. 10.
1890. *Onychiopsis elongata* NATHORST : Beiträge z. Mesozoische Flora Japans. P. 4, pl. I., figs. 1-3, pp. 8, 10, 13, 14, pl. VI., fig. 5.
1894. *Onychiopsis elongata* YOKOYAMA : Mesoz. Plants from Kozuke, Kii and Tosa. P. 215, pl. XX., fig. 8 ; pl. XXI., figs. 1 and 4.
- ? 1884. *Onychiopsis elongata* SEWARD : Wealden Flora I. P. 55, pl. II., fig. 2.
- ? 1896. *Onychiopsis elongata* KRASSER : Beitr. z. Kenntniss d. Foss. Kreideflora v. Kunstadt. P. 121, pl. VII, fig. 1.

This elegant fern is exceedingly common in the plant bearing beds of Naktong, although it is not easy to obtain specimens sufficiently large and well preserved to show the entire frond. Not seldom, large blocks of shales are found containing innumerable fragments of pinnae frequently bearing fructification. On pl. I. and II., some of the specimens are figured ; all of them show the characteristic features of the species, quite agreeing with the description and figures of the Japanese specimens in Prof. YOKOYAMA's works.

Prior to YOKOYAMA's publication, Mr. S. MATSUSHIMA, in his "Geological Report of the Eastern Part of Echizen including the Upper Tetorigawa Region" 1883 (MS.), described a fern under the name of *Sphenopteris Mantelli*, much like *Thyrsopteris elongata* GEYLER but more slender in appearance. This specimen is reproduced here in pl. I., fig. 12, from which we know that it is almost indistinguishable from the drawings of European

Sphenopteris Mantelli given in various publications. As in the Japanese and the Korean examples, the foreign specimens seem equally variable so that SEWARD once distinguished a form with broader pinnules from those with narrower.

SEWARD also referred some of the ferns described as *Sphenopteris Goepperti* by SCHENK to *Onychiopsis elongata*, which was subsequently verified by KRASSER's reëxamination of the original specimen of SCHENK. Besides, KRASSER added that there was a great probability that the specimen referred to the Japanese species was a narrow leaved form of *O. capsulifera* (VELONOWSKY). SEWARD is also of the opinion that the distinguishing characters given of *O. Mantelli* and *O. elongata* are not of sufficient importance to render them separate species.

In the collection from Korea, there are many pinnae with fructification; the fertile pinnules agree with the Japanese specimens both in their dimensions and in their mode of arrangement on the axis. They are arranged on the axis sometimes quite distant from one another as in the figures of the present work, sometimes very close as in the GEYLER's drawings. SEWARD described the fertile pinnules of *O. Mantelli* as sessile or short-stalked, and VELONOWSKY's illustration of *O. capsulifera* also clearly shows the same character. A specimen of *O. elongata* which GEYLER figured, belongs to the upper portion of pinnae with fertile pinnules which are crowded together and furnished with short stalks. Specimens from Korea differ from those above mentioned in having, "the sori placed two at the end of each pinnule, which is considerably narrowed looking like a winged stalk", as Prof. YOKOYAMA aptly expressed it in his description of the Japanese specimens.

A comparison of the fertile pinnules of *O. Mantelli* with

those of *O. elongata* shows a slight difference in form. In the former, the apical portion is more elongated while, in the latter, it is usually rounded instead of being acuminate.

However great the resemblance may be between the oriental and the European species, the writer considers it at present proper to keep them as two distinct species, as there are slight differences in the form of the fertile pinnules and in the general habits of the sterile pinnae.

An examination of numerous figures of the species of *Thyrsopteris* described by FONTAINE from the Potomac formation of Virginia,¹⁾ shows many forms more or less closely allied to the Japanese species. This fact was already pointed out by the author of the Wealden Flora who placed *T. rarinervis* FONTAINE among the synonyms of *O. elongata*. However, until a direct comparison of the specimens from both sides is made, the question must be left unsettled. SEWARD also compared *Asplenium dicksonianum* HEER²⁾ from the Kome-beds of Greenland with the present species, their external resemblance at least being very striking. HEER placed the fossil under the genus *Asplenium*, because he was convinced of its relation to the living *Asplenium nigrum* L.. But there is no fructification to decide the question.

Schenk³⁾ determined a specimen from Japan in one of RICHTHOFEN's collections of fossil plants, as *Thyrsopteris elongata* GEYLER, to which Prof. YOKOYAMA and SEWARD also seem to agree although the pinnules are apparently too broad to allow this identification to pass unquestioned. It reminds some of

1) FONTAINE: Potomac Flora p. 123, pl. XXVI, figs. 6 & 7; pl. XLIII, figs. 4-6 pl. XLIV, figs. 1, 2, 5; pl. XLIX, fig. 2; pl. CLXIX, figs. 6, 4, 7.

2) HEER: Fl. Foss. Arct., III., p. 31, pl. I.

3) SCHENK: Fossilen Pflanzen (RICHTHOFEN's China IV.), p. 263, pl. LIV., fig. 1.

what HEER, Prof. YOKOYAMA and others described as *Thyrsopteris*; and it is also in some respects not unlike *O. capsulifera*.

In this connection, the present writer figured (pl. I., fig. 12) a specimen from Shimamura, Prov. Kaga, one of the localities in Japan which are prolific of Jurassic plants. It shows a character very much like SCHENK's *Thyrsopteris elongata*, and at first it was taken for the same. But on making a thorough examination of the fertile portion of the frond, it was found not to belong to the genus *Onychiopsis* but in all probability to *Coniopteris*. Although the plant will not be described here, the above fact forces the present writer to doubt SCHENK's determination above alluded to.

CYATHEACEAE.

CONIOPTERIS *Brongniart*.

(Tableau Foss. Veg. p. 26).

In agreement with to SAPORTA, SOLMS LAUBACH and SEWARD, the following fossils are described below under the generic name of *Coniopteris*, on account of the external resemblance of their fructification to that of some recent genera of Cyatheaceae (especially of *Dicksonia* and *Thyrsopteris*). For such forms, some authors are accustomed to use the generic names of the living ones, even when the real nature of the sori and sporangia is unknown.

CONIOPTERIS HEERIANUS (YOKOYAMA).

Pl. II., fig. 8; pl. III., figs. 9, 14.

1889. *Adiantites Heerianus* YOK.: l. c. p. 28, pl. XII., figs. 1, 1a, 1b, and 2.

Frond bipinnate, ovate; principal rachis slender, but stout and straight, partly winged; pinnae oblique (making an angle of about 40° – 50° with the principal rachis), rather distant from one another, long, rapidly becoming shorter toward the anterior portion of the frond; pinnules rather distant, alternate, oblongly rhomboidal, gradually tapering below, and lobed; lobes small, acutely directed forward, acute at apex; venation very fine and indistinct, median vein sending off alternately into the lobes branches which fork once or twice. Leaf substance coriaceous?

The pinnae of the anterior part of the frond are simple-lobed. The sori which are found on these pinnae are reniform, fixed to the margin of each lobe, at the end of the vein; usually there is one sorus on the inner margin of the lobe, but sometimes many along the inner as well as the outer margin. Each anterior portion of the posterior pinnae is also simple-lobed, without being cut so as to form separate pinnules.

After a careful study, the writer was convinced of the identity of the examples with a Japanese species, very rarely found in the plant-bed of Shimamura, prov. Kaga. The Korean and the Japanese examples are precisely similar in characters, but it is necessary to note that the type specimens from Japan consist of but four fragmental pinnae, for which Prof. YOKOYAMA gave the following diagnosis:

“Pinnae elongated ; pinnules alternate, acutely directed forward, rhomboidal, attenuated below, acute at apex, acutely lobed ; veins equal, fine, repeatedly dichotomous.”

Prof. YOKOYAMA brought two pinnae, which differ from each other in the size and form of the last segments, under the species in question and quite rightly, as the Korean material shows that the pinnae of the posterior portion of a frond possess broad segments while those of the anterior portion present narrow ones. As to the identity of the Korean and Japanese forms, a comparison of a specimen shown in fig. 8, pl. II., with fig. 1a in pl. XII of Prof. YOKOYAMA will place it beyond all doubt.

In one of the Japanese examples, all of the pinnules show dark dots around their margin borne on the tip of each lobe ; the fructified example from Korea, fig. 9, pl. III., being distinctly the apical portion of a frond, shows pinnae which are simple-lobed instead being deeply divided into pinnules ; and the lobes which sometimes bear more than one sorus along the inner margin are only the posterior ones. From this, it is highly probable that the fructified example from Japan figured by Prof. YOKOYAMA is from the posterior portion of a frond.

The writer has brought this species under the genus *Coniopteris* for its fructification obviously resembles, at least in its external appearance, some of the recorded cases of fossil *Dicksonia* and of the living representatives of the same genus. Yet it must be admitted that with the material at the writer's disposal it has been impossible to examine in any way either the real nature of the sori, indusium and sporangia, or the anatomical characters of the stem. Prof. YOKOYAMA placed his species in the genus *Adiantites*, although he admitted the resemblance of its fructifica-

tion also to *Dicksonia* ; SEWARD,¹⁾ however, brought it within the synonyms of *Coniopteris hymenophylloides* with a query.

The sterile pinnae of this species are so much like those of *Dicksonia acutiloba*,²⁾ *D. concinna*³⁾ and *D. Saportana*⁴⁾ from the Jurassic Deposits of eastern Siberia, that the writer at first hesitated to separate it from any of those species. But the distinctly contracted base of the pinnules and other minute differences led him to make it separate from the Siberian species. Among the Potomac plants, there are also many species allied to the Japanese, such as *Thyrsopteris elliptica* FONTAINE,⁵⁾ *T. varians* FONTAINE⁶⁾ and *T. crenata* FONTAINE,⁷⁾ none of which however seems to be quite identical with it.⁸⁾

CONIOPTERIS HYMENOPHYLLOIDES (BRONGNIART) ?

Pl. II., fig. 8 ; pl. III., fig. 8.

1851. *Sphenopteris nephrocarpa* BUNBURY : On Some Fossil Plants from the Jurassic Strata of the Yorkshire Coast. Quart. Jour. Geol. Soc. London. Vol. VII., pl. XII., figs. 1a, b, p. 179.

1) SEWARD : Jurassic Flora, p. 100.

2) HEER : Beiträge z. Jura-flora Ostsibiriens u. d. Amurlandes, p. 92, pl. XVIII., fig. 4.

3) HEER : l. c. p. 34, pl. XIV., fig. 6 ; p. 87, pl. XVI., figs. 1-9.

4) HEER : l. c. p. 89, pl. XVII., figs. 1, 2 ; pl. XVIII., figs. 1-3.

5) FONTAINE : Potomac Flora, p. 133, pl. XXIV., fig. 3 ; pl. XLVI., fig. 1 ; pl. L., figs. 6, 9 ; pl. LI., figs. 4, 6, 7 ; pl. LIV., fig. 6 ; pl. LV., fig. 4 ; pl. LVI., figs. 6, 7 ; pl. LVII., fig. 6 ; pl. LVIII., fig. 2.

6) FONTAINE : l. c. p. 137, pl. LII., figs. 2-4 ; pl. LII., figs. 1-3 ; pl. LIV., fig. 10 ; pl. LVII., fig. 2.

7) FONTAINE : l. c. p. 127, pl. XXXIX., figs. 1-2.

8) In a piece of shale with a sterile frond of the species, there is an impression which looks as if it were a portion of a tree fern stem 3.5 cm. in length and 2.5 cm. in breadth. It shows an obliterated surface only, the vascular bundles being not quite recognizable. The petiole bases are arranged in close spirals.

1863. *Hymenophyllites Bunburyanus* FEISTMANTELL: Jurassic Flora of the Raymahal Group. P. 78, pl. XXXII., figs. 5-7.
1864. *Tympanopora racemosa et simplex* LECKENBY: On the Sandstones and Shales of the Oolithes of Scarborough. Quart. Jour. Geol. Soc. London. Vol. XX., p. 79, pl. XI., fig. 2.
1876. *Thyrsopteris Murrayana* HEER: Beiträge z. Jura Flora Ostsibiliens u. des Amurlandes. P. 30, pl. I., fig. 4; pl. II., fig. 4; pl. VIII., fig. IIb.
Thyrsopteris Maakiana HEER: l. c. P. 31, pl. I., fig. 1; pl. II., fig. 5.
Dicksonia clavipes HEER: l. c. P. 33, pl. II., fig. 7.
1878. *Thyrsopteris Murrayana* HEER: Nachträge z. Jura-flora Sibiriens. P. 6, pl. I., fig. 1.
1889. *Dicksonia nephrocarpa* YOKOYAMA: l. c. P. 25, pl. I., figs. 1, 1a.
1895. *Thyrsopteris* (?) *Murrayana* RACIBORSKY: Flora Kopalna. P. 180, pl. X., figs. 15, 16; XII., 17-21.
Dicksonia (*Eudicksonia*) *Heerii* RACIBORSKY: l. c. P. 174, pl. X., figs. 5, 6a, 7-11a, 12-14.
Dicksonia Zarecznyi (par.) RACIBORSKY: l. c. P. 175, pl. XII., figs. 8, 9, 11, 12.
1900. *Coniopteris hymenophylloides* SEWARD: The Jurassic Flora. Yorkshire. P. 99, pl. XVII., figs. 6 and 8; pl. XXI., figs. 2-4.

Two fertile pinnae are referred by the writer with doubt to the well known, and widely distributed species, *C. hymenophylloides*, whose fertile pinnae have been described under various names from different localities, for example, *Sphenopteris nephro-*

carpa, *Tympanopora racemosa* and *T. simplex* from Yorkshire, *Dicksonia clavipes*, *Thyrsopteris Murrayana*, *T. Maakiana* from Siberia and *Dicksonia* (*Eudicksonia*) *Heerii*, *D. Zarecznyi* from Cracow. What are known under these different names have subsequently been proved to be simple modifications of the fertile segments of *Coniopteris hymenophylloides*, and the presence of a gradual transition in these fertile pinnae from forms with a few broad and round lobes to those with narrow, deeply dissected segments, has been traced by SEWARD in materials found at Scarborough.

NATHORST united *Dicksonia clavipes* HEER, from Kaja in Siberia, with *Sphenopteris nephrocarpa* BUNBURY; then, Prof. YOKOYAMA described a fertile pinna from Japan of precisely similar nature as *Dicksonia nephrocarpa*. *Sphenopteris* (*Hymenophyllites*) *Bunburianus*¹⁾ from India is also no doubt a close ally, if not identical.

One of the fructified examples from Korea, being quite similar to *Sphenopteris nephrocarpa* figured by BUNBURY from the Yorkshire Jurassic, is a bipinnatifid fragment with an almost straight and slender rachis about 2.5 cm., and alternate pinnae (4 on one side) attached to the rachis at a wide angle. The pinnae are but slightly flexuous and are furnished with alternate pinnules. A round sorus is on the dilated margin of each pinnule or lobe, which is contracted below and at the end of the vein.

In an other example, the lamina of the segments is much more reduced; each pinnule has usually a single cup-shaped (?) sorus; some of the lower portion however have the lamina less reduced and bear 2 or more sori.

1) OLDHAM and MORRIS: Pal. Indica, pl. XXXII., p. 54. HEER took it to be *Thyrsopteris Maakiana*; and SEWARD referred it with some doubt to *Coniopteris hymenophylloides*.

*Genera of Uncertain Systematic Position.***CLADOPHLEBIS**, BRONGNIART.**CLADOPHLEBIS** cfr. **DENTICULATA** (BRONGNIART).

Pl. III., fig. 11.

The only specimen obtainable being fragmentary, it has been impossible to make an exact specific determination. Only the apical portion of a pinnae is shown, about 4 cm. in length, bearing seven pinnules on one side of the slender rachis. The pinnules are more or less falcate, rapidly narrowing forward to the acute apex, and show a few serrations along the margin; they are separate, but are set close together, being attached by the whole base. The venation is fine but quite distinct; the median vein is somewhat flexuous, and the lateral veins are distant, opposite, directed acutely forward and forked once near the base.

Fragmentary as the specimen is, its resemblance to *Cladophlebis denticulata* (BRONGN.) is considerable, all the characters seen in it being quite similar to those of this well known Jurassic species.

The full account of *C. denticulata* is given in the Jurassic Flora Pt. I., p. 134.

CLADOPHLEBIS KORAIENSIS sp. nov.

Pl. II., fig. 1; pl. III., figs. 12, 13.

Frond tripinnate in the anterior portion and quadripinnate in the posterior; main stalk longitudinally striated, rather broad

and strong. Pinnae usually linear, subopposite, leaving the rachis at an angle of about 45° or more; or, as is sometimes the case, standing perpendicular to the rachis; close together so as to overlap in the posterior portion of the frond. Pinnules vary considerably in size and form; those in the posterior part being generally very narrow, linear, often finger-shaped and falcate; decurrent at base, giving the rachis a slightly winged aspect; they are usually close together but sometimes quite remote from one another; serrate along the margin, the teeth gradually changing into numerous small trigonal segments. Anterior pinnules close together, varying in form from a short and more or less trigonal one to lanceolate, with the front margin usually straight and the back more or less strongly convex and with a bluntly pointed apex; attached by the whole of the broad base to the rachis. Median vein well preserved, scarcely reaching to the summit of the pinnule; lateral veins very obscure, somewhat distant, oblique and with single bifurcation. Sori large in proportion to the pinnules, nearly round, very prominent, appearing as pustular elevations on the upper surface; crowded, arranged in a single row on each side of the median-vein; fertile pinnules somewhat rolled up along the margin, with lateral veins quite obscure. Even by SCHULZE's method, it is not possible to determine the character of the sporangia or the spores.

Among the Japanese fossils, there are many forms, more or less closely related to this Korean species. First of all, there is *Pecopteris exiliformis*¹⁾ of GEYLER, who pointed out its close resemblance to *P. exilis*. Subsequently, however, Prof. YOKOYAMA²⁾ considered this Scarborough species as itself represented in the

1) GEYLER: Pflanzen a. d. Juraform. Japans, p. 226, pl. XXX., fig. 1a.

2) YOKOYAMA: Jurassic Plants, p. 35, pl. I., figs. 8, 10.

Japanese Jurassic flora and believed *P. exiliformis* to be in reality no other than this species; but subsequently, he expressed the opinion that the Tetori form might possibly belong either to *P. Browniana* or *P. Geyleyriana*; NATHORST also pointed out the great resemblance existing between *P. exiliformis* and his *P. Geyleyriana*; ¹⁾ and SEWARD ²⁾ is of the opinion that *P. exilis* from Japan is probably identical with, or at least very close, to *P. Browniana*; and *P. exiliformis* also does not suggest a plant with a well marked specific difference.

According to BUNBURY ³⁾ and RACIBORSKY ⁴⁾ who described the fertile pinnules of *P. exilis*, the sporangia possess an apical annulus, and are in a single row on each side of the median vein; hence the latter author was led to propose the new generic name *Klukia* for the above fossil, which shows a decided affinity to Schizaeaceae.

The round dots in the Korean examples are in all probability of a different nature from those of *Klukia exilis*, though there is a great resemblance between them. The present writer does not regard this resemblance as an evidence of relationship.

At any rate, fig. 9, pl. I. in Prof. YOKOYAMA's work exhibits a greater likeness to the Korean form than figs. 8 and 10 in the same plate. The example figured by GEYLER also resembles it.

The writer has examined some specimens of the *P. exilis* type from Hakogase, collected by Mr. S. MATSUSHIMA and now deposited in the Science College Museum. One of them is pre-

1) NATHORST: Mesoz. Flora Japans, p. 48.

2) SEWARD: Fossil Flora of Cape Colony.

3) BUNBURY: Quart. Jour. Geol. Soc. 1851. VII. P. 188, pl. XIII., fig. 5.

4) RACIBORSKY: Ueber die Osmundaceen u. Schizaeaceen d. Juraformation.

cisely similar to GEYLER's drawing, and hence also like figs. 8 and 10 in Prof. YOKOYAMA's work. The other examples show much resemblance to fig. 9 of the latter and evidently belong to the terminal and middle portions of the same fern.

The Japanese fern, so well illustrated by Prof. YOKOYAMA possesses oblong pinnules, in general differing from the Korean by a decidedly obtuse outline, often broader and rising from the rachis at a wider angle.

A similar fern was described by Prof. YOKOYAMA from Japan under the name of *Asplenium argutulum*; among the figures referred to this species, in pl. III., fig. 1, agrees well with the Chinese examples described by SCHENK; while those represented in fig. 9, pl. XIII. and fig. 22, pl. XIV., show a great resemblance to the Korean. Prof. YOKOYAMA had already made the remark that the latter two examples have a great resemblance to some forms of *P. Phillipsi* BRGT. (*P. exilis*). It is by no means improbable that some of these figures represent plants which are really identical with the Korean species. In the Ryoseki flora of Japan, there is *Cladophlebis Browniana*,¹⁾ a Wealden species of world wide distribution, associated with *C. Geyleriana* NATH.,²⁾ a hitherto solely Japanese form.

When NATHORST first described *P. Geyleriana*, he was unable to trace out the lateral veins of the pinnules, and therefore, though he possessed the fertile pinnae provided with round sori on each side of the median vein, he took it to be simply a species of *Pecopteris*. Its relation to *Lonchopteris* which he then suspected, was subsequently made impossible by Prof. YOKOYAMA's exami-

1) YOKOYAMA: Mesoz. Plants from Kozuke, Kii, Awa and Tosa, p. 218, pl. XXIV., figs. 2 & 3; XXVII., 1-4, 5c, d.

2) YOKOYAMA: l. c. p. 219, pl. XXI., figs. 1, 2; XXIII., 1a, 1; XXVIII., 5.

nation of better material which showed the pinnules with bifurcating lateral veins. Therefore, SEWARD¹⁾ thinks that possibly the fertile pinnae described by NATHORST should be kept as a species distinct from the sterile examples, and referred to *Weichselia* (*Lonchopteris*) *Mantelli*. In a more recent publication, SEWARD²⁾ has placed the specimens represented in figs. 2-6 of NATHORST's paper under *C. Browniana*, considering them as distinct from the others for which he retains the name of *P. Geyleriana*.

The present writer has mentioned above that the *P. exilis* of Prof. YOKOYAMA (*P. exiliformis* GEYLER) shows some slight differences from *C. koraiensis*, on account of which the Japanese species approaches to, or more likely is identical with, *C. Browniana*, as YOKOYAMA and SEWARD had already pointed out.

The fertile pinnae of *P. Browniana* figured by Prof. YOKOYAMA and those of *P. Dunkeri* of FONTAINE³⁾ from the Potomac, strongly suggest those of the living *Aspidium* in the form and mode of attachment of the sori, so that the latter author even went so far as to bring his *P. Dunkeri* under the genus *Aspidium*, although according to the writer's opinion these characters not seem to justify such an assumption.

Comparing the fertile pinnules of *C. koraiensis* with those of the two above mentioned, some differences still remain; also it is not wholly impossible, that the form belongs to a genus entirely different from the latter two.

To sum up, at present it seems advisable to treat the Korean form, as a new species of *Cladophlebis*, a genus created for the

1) SEWARD: Wealden Flora, I, p. 116.

2) SEWARD: Fossil Flora of the Cape Colony, p. 12.

3) FONTAINE: Potomac Flora, p. 101, pl. XXII., fig. 9.

reception of sterile fronds of ferns whose real relation to the living forms is unknown.

CLADOPHLEBIS cfr. **DUNKERI** (SCHIMPER).

Pl. IV., fig. 9.

Among numerous examples of fronds of the *Cladophlebis* type, there is one which closely resembles the Wealden species called *C. Dunkeri*. Possibly it may turn out to be an extremely modified form of the preceding species; but at present it is better treated as a different fossil.

The specimen shows a bipinnate fragment of a frond, with a stout principal axis from which the pinnae branch off at a wide angle. The pinnae are opposite and close; the pinnules are small, oblong, often slightly falcate, very close, attached to the rachis with a broad base.

It is almost impossible to draw a distinction between this fern and *C. Dunkeri* from the Potomac flora (Fontaine, Pl. XXVI., fig. 3.).

CLADOPHLEBIS sp. indet.

Pl. IV., fig. 8.

There are several fragments of isolated pinnae of a *Cladophlebis* which though too imperfect for specific determination, may be briefly described as follows:—

Pinnae lanceolate, rapidly tapering to an acuminate apex; pinnules elongated, gradually becoming oval toward the anterior part of the pinna; slightly pointed at apex and somewhat decurrent at base which is auriculate on the posterior side; margin slightly

undulating. Median vein thick, evanescent near the apex ; lateral ones obsolete, remote, subopposite, oblique and single-forked.

One of the pinnae measure 3 cm. in length and bears nine pinnules on one side of the rachis.

This species is evidently distinct from the foregoing two.

SPHENOPTERIS, BRONGN.

SPHENOPTERIS NAKTONGENSIS sp. nov.

Pl. IV., figs. 10, 11.

Fronde tripinnate, deltoid ; principal rachis slender, flexuous ; primary pinnae subopposite, rather remote, attached to the rachis at a wide angle, linearly oblong, pinnatifid ; ultimate pinnae alternate, very short, passing anteriorly into lobed pinnules ; pinnules oblong or cuneiform, alternate, oblique, decurrent on the slightly winged rachis, more or less deeply lobed ; lobes denticulated ; venation indistinct, veins very close, flabelately dichotomous.

Among the hitherto described ferns, there is none which is identical with this Korean fossil. *Ruffordia Geopperti*¹⁾ is the only one which more or less closely approaches it.

SPHENOPTERIS sp.

Pl. I., fig. 15.

Fronde bipinnate, rachis slender ; pinnae linear, springing almost at right angles from the rachis, pinnately lobed ; lobes

1) SEWARD Wealden Flora, I., p. 75.

obtuse, acuminate with entire margin; somewhat falcate; venation of a *Sphenopteris* type, that is to say, with a distinct median vein sending off an obsolete secondary vein into each lobe. Sori in two rows, one on each side of the median vein, placed near the base of each lobe and on the summit of the uppermost branch of the vein.

At a first glance, this form comes near to *Dicksonia Bindrabunensis* FEISTMANTEL¹⁾ from the Jurassic of the Rajmahal Hills, India, and *Alsophila polonica* RACIBORSKY²⁾ from the neighbourhood of Cracow. But, no detail of the fructification being observable in the only specimen at hand, its generic position is not certain.

ADIANTITES, GOEP.

ADIANTITES SEWARDI sp. nov.

Pl. I., figs. 1-8.

1888. *Rhacopteris*? sp. MATSUSHIMA: A Geol. Rep. of the East. Part of Echizen including the Upper Tetorigawa region, in Kaga. (MS.) P. 188, pl. VII., fig. 5.

Frond bipinnate, rachis thin and straight; pinnules alternate to subopposite, close but rarely imbricated; rounded at the upper margin and attenuated below to a narrow base, with a short de-

1) FEISTMANTEL: Jurassic Flora of the Rajmahal group in the Rajmahal Hills. P. 23, pl. XXXVII., figs. 2, 2a.

2) RACIBORSKY: Flora Kopalna ognitrawalych glinek Krakowskich. Archaeogoniatae. P. 29, pl. IX., figs. 3, 4.

current petiole. Lateral pinnules generally inequilateral, varying from subquadrilateral to fan-shaped, with inner margin parallel and very close to the rachis. Apical pinnules nearly equilateral, being broader than the others. Upper margin irregularly crenulated. Veins numerous, fine, uniform and distinct, united below at the base, widely spreading and dichotomously divided upward.

According to the general usage, this elegant fern is referred to the provisional genus *Adiantites* on account of its undoubted resemblance to some living species of *Adiantum* or *Lindsaya*.

Among the recorded species referred to *Adiantites* or sometimes to *Adiantum* itself, there are three species more or less allied to the present species; *Adiantites Tietzi* SCHENK¹⁾ from the Rhaetic of the Albours-chain, *Adiantum Szechenyi* SCHENK²⁾ from the middle Jurassic of China and *Adiantites yuasensis* YOK.³⁾ from the Ryoseki series of Yuasa in Japan. The resemblance of the Korean frond to the last species has already been pointed out by Mr. MATSUSHIMA.

In the first of these three species, the pinnules are more densely crowded and deeply imbricated; the other two species exhibit a somewhat different venation.

A species which is nearer to the Korean than any of the above three is *Adiantites longiquis* SAPORTA (Nouvelles Contributions a la Flore Mesozoique 1894. p. 40, pl. X., fig. 1.) from the Neojurassic deposit of Portugal. This species was founded by SAPORTA on a few fragmental pinnae with subopposite pinnules; however, so far as one can judge from the characters revealed

1) SCHENK: Fossile Pflanzen aus der Albours-kette, gesammelt von E. TIETZE. 1887, p. 3, pl. II., fig. 9.

2) SCHENK: Fossile Pflanzen (Graf. Szecheny's Reise Vol. III.) P. 163, pl. I., fig. 3.

3) YOKOYAMA: Mesoz. Plants from Kozuke, Kii, Awa and Tosa. P. 216, pl. XXI., fig. 15.

by the figures, the species so much resembles the Korean in form, size and the venation of the pinnules, that these two are no doubt very closely allied to each other, if not identical. The only distinction lies in a slight difference in venation.

The Japanese examples of this species have been obtained by Mr. MATSUSHIMA from Kinebashi, Uchinami and Otani, Onogori, prov. Echizen.

FILICES?

SAGENOPTERIS, PRESL.

SAGENOPTERIS BILOBATA sp. nov.

Pl. III., figs. 16a, b, c.

There are two forms of *Sagenopteris* hitherto described from the Jurassic deposits of Yorkshire and others, which are usually found together. The pinnules in the one are lanceolate in outline, while those of the other are cuneate at base; and these had been kept for a long time as two distinct species, but at present the cuneate form is considered to be an imperfect or abnormal state of the frond of the same species; thus in the case of the Yorkshire flora, SEWARD¹⁾ distinguished these two forms under the names of *S. Phillipsii* var. *cuneata*, and var. *major*.

In the Korean specimens, there are two types; the one represented by three examples, shows an outline precisely similar to *S. cuneata* or *S. Phillipsii* var. *cuneata*, while the other three slightly differ from var. *major*.

1) SEWARD: Jurassic Flora, I. P. 162.

The first of them consists of two obtuse pinnules, in contact, borne on a stipe; the pinnules bear no median vein, but are traversed by spreading anastomosing veins. The second is a linear pinna, apically cleft into two symmetrical lobes, with a median vein. Its lateral veins are very fine, anastomosing, leaving the median vein at an acute angle.

Though at first the writer took the latter type as specifically identical with *S. Phillipsii* var. *major*, the bilobed nature of the pinnules of the Korean plant led him at last to regard it as a different species. Such being the case, he believes it best to treat the two types of the Korean examples as a single species, but calling them for distinction, var. *cuneata* and var. *major* directly after the example of *S. Phillipsii*.

Another point of distinction of some value between *S. Phillipsii* and *S. bilobata* is found in the outline of the pinnules which are lanceolate in the former and linear in the latter.

Another allied species which merits mention is *S. tasmanica* FEISTMANTEL¹⁾ from the Carbonaceous beds (upper Mesozoic) of the Jerusalem basin, Tasmania. The species was founded by FEISTMANTEL on a single example which shows a portion of two lobes of a three-lobed frond as he understood it. Each lobe is linear, attenuated above and provided with a median vein, quite distinct in the greater part of the length though disappearing in the apical portion, and with lateral veins passing out from the median vein at an acute angle and forming a single anastomosis.

A comparison of this species with the Korean is rendered, however, almost impossible so far as the outline is concerned,

1) FEISTMANTEL: Geological and Palaeontological Relations of the Coal- and Plant-bearing Beds of Palaeozoic and Mesozoic age in Eastern Australia and Tasmania, p. 135, pl. XXIX., fig. 6.

owing to the want of the basal portion of the frond in the former and of the apical portion in the latter; but if FEISTMANTEL'S explanation is correct, then their relationship is only a slight one, for he understands his specimen to be a probably three-lobed frond while the Korean species is only two-lobed, the resemblance being solely due to the mode of preservation.

A similar dichotomization of the frond is also well shown by *Phlebopteris* (?) *dichotoma* SHIRLEY¹⁾ from the Denmark Hill, Ipswich, Queensland.

EQUISETALES.

EQUISETUM, L.

EQUISETUM USHIMARENSE YOK.

Pl. III., fig. 10.

1889. *Equisetum ushimarense* YOK.: l. c. p. 39, pl. XI.,
figs. 1-3.

A few fragments of rhizomes of an equisetaceous plant are in the writer's collection. Their breadth varies between 2.5 mm. and 6 mm., with three to four, strong ribs and internodes, 2.0-2.5 cm. apart. Tubercles rarely found are ovate in form, measuring 1.8 cm. in length and with no surface markings visible on thier surface.

A comparison between the present examples and the figures of Prof. YOKOYAMA'S species leaves no doubt about their specific identity.

1) J. SHIRLEY: Additions to the Fossil Flora of Queensland, p. 24, pl. XV., fig. 2.

The Japanese species is so much like *E. Burchardi* SCHENK from the European Wealden formation, that there is a doubt that they are really different plants. However, their identity being not yet fully verified, the above name has been here adopted.

GENERAL REMARKS AND CONCLUSIONS.

Constitution of the fossil flora:—Though sufficient material has not yet been collected to warrant an exhaustive discussion of the fossil flora, yet there are some points of importance with regard to the geological age of the Naktong series and its floral constitution, which call for a brief statement in this place. Indeed, the geological importance of these fossils lies in the circumstance that they are derived from the base of a very thick complex which affords no other reliable organic remains for determining its geological age.

As will be seen from the above description, the writer was enabled to distinguish the following twenty-one species of plants, of which 3 are new, and 7 of doubtful affinity.

<i>Dictyozamites falcatus</i> (MORRIS)	common.
<i>Nilssonia orientalis</i> HR.	abundant.
<i>N.</i> sp.	rare.
<i>Dioonites</i> (?) sp.	rare.
<i>Ctenophyllum</i> (?) sp.	rare.
<i>Podozamites Reinii</i> GEYLER	rare.

<i>P. lanceolatus</i> (LINDLE. & HUTTON)	rare.
<i>Pinus</i> sp.	common.
<i>Pinus</i> sp.	common.
<i>Onychiopsis elongata</i> (GEYLER)	abundant.
<i>Coniopteris Heerianus</i> (YOKOYAMA)	common.
<i>C. hymenophylloides</i> (BRONGN.) (?)	rare.
<i>Cladophlebis</i> cfr. <i>denticulata</i> (BRONGN.)	rare.
<i>C. koraiensis</i> sp. nov.	abundant.
<i>C.</i> cfr. <i>Dunkeri</i> (SCHIMMER)	rare.
<i>C.</i> sp.	rare.
<i>Sphenopteris naklongensis</i> sp. nov.	common.
<i>S.</i> sp.	rare.
<i>Adiantites Sewardi</i> sp. nov.	abundant.
<i>Sagenopteris bilobata</i> sp. nov.	rare.
<i>Equisetum ushimarensense</i> YOK.	common.

In the constitution of the flora, Filices form of the most important part, being represented by 6 genera and 11 species. Among these, three species are found in great abundance. Cycadophyta, though fairly common, are less frequent than the ferns, being represented by 5 genera and 7 species. Equisetaceae and Coniferae, though not rare, are all not clearly determinable. It is very striking that the fern fronds are generally in a fertile state, just as in the fire-clay of Cracow, described by Raciborsky. Such are *Onychiopsis elongata*, two species of *Coniopteris*, and one species of *Sphenopteris*; likewise the pinnae of *Cladophlebis koraiensis* mostly show the fructification.

Geological relation of the fossil flora:—From the above list it is quite evident that the flora is Jurassic, for neither typically Rhaetic nor Cretaceous forms are found in it; the form which may be assigned with hesitation to the Wealden type is but a single

one, that is, *Cladophlebis* cfr. *Dunkeri*.¹⁾ As usually accepted by paleophytologists, the vegetative character of the world from the upper Triassic to the Wealden seems to have been remarkably uniform and constant in its main features.²⁾ Hence it is a very difficult task to make out the exact age of a given plant-bed if it is poor in fossil contents, as in the present case. Though we have now twenty-one species in all, many are not available for this purpose.

Even of specifically determinable forms, *Onychiopsis elongata* seems to be of no value in settling this question, for it is a fern type of decidedly east Asiatic origin, thence becoming widely diffused in other lands after the Jurassic age. The fern with fronds of the *Cladophlebis denticulata* type is not only exclusively Jurassic, but is found also in the older as well as in the younger strata. The two fertile pinnae which the writer has compared with *Coniopteris hymenophylloides*, and the detached leaves of Coniferae also afford us no sure basis for a chronological correlation, because a determination based on such fragments must always be uncertain. *Podozamites lanceolatus* and equisetaceous remains seem equally of little value in this respect.

Excluding the above species and such as are new or doubtful, there remain only five species, viz. *Adiantites Sewardi*, *Coniopteris Heerianus*, *Dictyozamites falcatus*, *Nilssonina orientalis*, and *Podozamites Reinii*, which are available for determining the age of the strata.

According to Mr. S. MATSUSHIMA,³⁾ *Adiantites Sewardi* occurs at Kinebashi, Uchinami and Ōtani, Ōnogōri, prov. Echizen,

1) SEWARD: took *Equisetum Ushimarcense* as a Wealden type.

2) SEWARD: *Floras of the Past: their Composition and Distribution*. Pp. 13–22.

3) MATSUSHIMA: *A Geol. Rep. of the East. Part. of Echizen etc.* (MS.), p. 188.

associated with *Podozamites lanceolatus*, *Cladophlebis* sp. (*C. aff. Dunkeri*) and *C. sp.* (*C. aff. distans*).

Coniopteris Heerianus and *Podozamites Reinii* are exclusively Japanese Korean species; the latter is especially widely spread in the Japanese Tetori series; Prof. YOKOYAMA¹⁾ described it from Okamigō, prov. Hida, Tanimura, prov. Echizen, Ozō, Yanagidani and Shimamura, prov. Kaga; at the last locality it is found together with *Coniopteris Heerianus*. The other fossils found in association with these species are, according to the above author, at Shimamura, *Thyrsopteris prisca*, *T. kagensis*, *Dicksonia gracilis*, *D. acutiloba*, *D. nephrocarpa*, *Onychiopsis elongata*, *Adiantites Kochibeanus*, *Asplenium Whitbiense*, *A. argutulum*, *A. distans*, *Pecopteris exilis*, *P. Supportana*, *Macrotaeniopteris* cfr. *Richthofeni*, *Anomozamites* sp., *Nilssonina nipponensis*, *Dioonites Kotōei*, *Zamitis parvifolius*, *Podozamites lanceolatus*, *P. tenuistriatus*, *Dictyozamites grossinervis*, *Cycadospermum japonicum*, *Ginkgodium Nathorsti*, *Ginkgo sibirica*, *Taxites* sp., *Pinus prodromus*, *P. Nordenskjoldi*, *Palissya* sp., and *Vallisnerites jurassicus* (?); at Yanagidani, *Onychiopsis elongata*, *Asplenium Whitbiense*, *A. distans*, *Taeniopteris* (?), *Sagenopteris* sp., *Nilssonina ozoana*, *N. (?)*, *Dictyozamites falcatus*, *Czekanowskia rigida*, *Taxites* sp., *Vallisnerites jurassicus* (?) and *Carpolithes ginkgoides*; from Tanimura *Thyrsopteris kagensis*, *Onychiopsis elongata*, *Dioonites Kotōei*, *Podozamites lanceolatus*, *Pinus*. cfr. *prodromus*; from Okamigō, *Thyrsopteris Murrayana*, *Dicksonia gracilis*, *Onychiopsis elongata*, *Asplenium argutulum*, *Equisetum* sp., *Nilssonina nipponensis*, *Podozamites lanceolatus*, *P. tenuistriatus*, *P. sp.*, *Ginkgodium Nathorsti*, *Ginkgo digitata*, *Czekanowskia rigida* and *Taxites* sp.

1) YOKOYAMA: Jurassic Plants from Kaga, Hida and Echizen.

Nilssonia orientalis is also known from Japan and Siberia. According to Prof. YOKOYAMA, it seems to be abundant in a plant-bed exposed at Hakogase, Ōnogōri, prov. Echizen, where *Dicksonia Glehniana*, *Onychiopsis elongata*, *Adiantites lanceus*, *Asplenium argutulum*, *A. distans*, *Sphenopteris* sp., *Podozamites lanceolatus* and *Ginkgo* cfr. *lepidus* are also found. The Jurassic deposit of Ajakit on the Lena¹⁾ whence the species was first recorded, contains, besides, *Dicksonia gracilis*, *D. borealis*, *Rhizocarpites singularis*, *Anomozamites angulatus*, *Nilssonia comtula*, *Podozamites lanceolatus*, *P. gramineus*, *Phoenicopsis angustifolia*, *Ginkgo Huttoni*, *G. sibirica*, *G. integriscula*, *Czekanowskia cretacea*, *C. rigida* and *Pinus Nordenskjoldi*. Recently, NATHORST²⁾ described an identical or closely allied form from the southern side of Sassen Bay, Spitzbergen; the only other fossil associated is *Ptilozamites* sp.

According to present knowledge, the distribution of the species of the genus *Dictyozamites* is confined to India, Japan, Korea, Bornholm and Yorkshire. A full account of the genus has been very recently written by SEWARD³⁾ who has pointed out the uniformity of the general features of the Jurassic floras of these widely distant places.

From these localities, three or four species are already known. The Korean and the Japanese fossils make a closer approach to *D. falcatus* from India than to those from other countries. In Japan, the species is found in the plant-bed of Ozō, prov. Kaga and Ushimaru, prov. Hida; the associated fossils at the former place have already been given above; those at the latter are *Asplenium distans* and *Podozamites lanceolatus*.

1) HEER: Beitr. z. Jurafloa Ostsibiriens u. d. Amurlandes, p. 18.

2) NATHORST: Zur Mesoz. Flora Spitzbergens, p. 24.

3) SEWARD: Occurrence of *Dictyozamites* in England.

In the Rajmahal group of India, *Dictyozamites falcatus* is found associated with the following species:—at Amrapara, *Angiopteridium* Mc. Clellandi, *Ptilophyllum cutchense*, *Williamsonia* sp., *Echinostrobus rajmahalensis*; at Murrero, *Angiopteridium spathulatum*, *Macrotaeniopteris crassinervis*, *Pterophyllum Medlicottianum*, *Zamites proximus* and *Zamiostrobus*; at Godavari, *Palissya conferta*, *P. indica*, *Cheilolepis* cfr. *Münsteri*, *Araucarites macropterus*, *Angiopteridium ensis*, *A. spathulatum*, *Ptilophyllum acutifolium*, *P. cutchense*, *Pterophyllum Morrisianum*, *P. Kingianum*, *P. distans*, *P. Carterianum* and *Williamsonia gigus*, *Alethopteris indica* and *Asplenites macrocarpus*. A similar association is also observed in the Sripermatur group and in the Vema varam beds of the Madras coast.¹⁾

It has been above pointed out that there are five species surely common to the Japanese and Korean floras. But there are, besides, seven less certain or simply allied forms, so that the total number which admits comparison is twelve. They are the following:—

Japan.	Korea.
<i>Dictyozamites falcatus</i> (MORRIS)...	<i>Dictyozamites falcatus</i> (MORRIS)
<i>Nilssonia orientalis</i> HR.....	<i>Nilssonia orientalis</i> HR.
<i>Dioonites Kotōei</i> YOK.....	{ <i>Dioonites</i> sp. <i>Ctenophyllum</i> (?) sp.
<i>Podozamites lanceolatus</i> LINDL....	<i>Podozamites lanceolatus</i> LINDL.
and HUTTON.	and HUTTON.
<i>P. Reinii</i> GEYLER.....	<i>P. Reinii</i> GEYLER.
<i>Pinus Nordenskjoldi</i> HR.	<i>Pinus</i> sp.

1) FEISTMANTEL: Jurassic Flora of the Rajmahal Group, in the Rajmahal Hills.—Jurassic Flora of the Rajmahal group of the Golapili.—The Fossil Flora of the Upper Gondwanas Outliers of the Madras Coast.

- Pinus* cfr. *prodromus* HR.....*Pinus* sp.
Coniopteris Heerianus (YOK.) ...*Coniopteris Heerianus* (YOK.)
Onychiopsis elongata (GEYLER)...*Onychiopsis elongata* (GEYLER)
Dicksonia nephrocarpa (BUNB.)...*C. hymenophylloides* (BRONGN.)
Asplenium distans HR. }*Cladophlebis koraiensis*
A. argutulum HR. }
A. argutulum HR. }*C. cfr. denticulata* (BRONGN.)
Pecopteris exilis PHILL. }
Adiantites Sewardi*Adiantites Sewardi*
Equisetum ushimarense YOK.....*Equisetum ushimarense* YOK.

As may be seen from the above, the general features of the two floras are essentially the same, so that their contemporaneity is quite evident.¹⁾

Prof. YOKOYAMA,²⁾ in his elaborate work on the Jurassic plants from Kaga, Hida and Echizen, assigned most of the fossiliferous beds to the Bathonian age, which view was subsequently accepted by NATHORST³⁾ and others. However, WARD⁴⁾ and SEWARD⁵⁾ among others point out the presence in the flora of many plants of Wealden types, suggesting that the plant-beds are of the lower Cretaceous age.

In a paper recently written on the Ammonites from Echizen, Prof. YOKOYAMA⁶⁾ states his conclusion that at least a part of the Tetori series is younger than the Bathonian and must be of the Malm age.

1) In this place, it should also be borne in mind that the Jurassic districts of Kaga, Hida and Echizen in Japan and of Kyōng-syang-Do in Korea are nearly in the same latitude.

2) Page 19.

3) NATHORST: Beitr. z. Mesoz. Flora Japans.

4) WARD: Geographical Distribution of Fossil Plants, p. 789.

5) SEWARD: Wealden Flora, I, p. 32.

6) YOKOYAMA: Jurassic Ammonites from Echizen and Nagato, p. 3.

As it appears from previous writings on the geology of the said region, the plant bed of Kinebashi, Uchinami and Ōtani with *Adiantites Sewardi*, and that of Hakogase with *Nilssonia orientalis* lie immediately upon the Ammonites-bed of propably the lower Malm age, and Prof. YOKOYAMA, in his paper, suspects that the plant bed of Ozō, prov. Kaga, with *Dictyozamites falcatus*, may possibly be somewhat older than the Bathonian; taking it as a whole, the Tetori series seems to represent a phase of the Jurassic in the narrowest sense of the word (i.e. Malm and Dogger).

The resemblance of the Japanese flora to the Siberian was pointed out by GEYLER;¹⁾ HEER²⁾ also mentioned that *Thyrsopteris elongata* of GEYLER is a type of fern very common in the Siberian Jurassic. Prof. YOKOYAMA's renewed examination of the rich material of the Tetori flora revealed that 16 out of 36 species are found in Siberia.³⁾

Beside *Nilssonia orientalis*, there are other forms common to Siberia and Korea, such as *Coniopteris hymenophylloides*, *Cladophlebis denticulata*, *Pinus Nordenskjoldi*, *P. prodromus* and *Podzamites lanceolatus*. These, however, are cosmopolitan forms, also found in Japan and China.

From China and Mongolia, NATHORST,⁴⁾ SCHENK,⁵⁾ ZEILLER,⁶⁾

1) GEYLER: Ueber Fossile Pflanzen aus der Juraformation Japans.—Ueber Einige Paläontologische Fragen, insbesondere über die Juraformation Nordostasiens.

2) HEER: Nachträge z. Jura-flora Sibiriens, p. 4.

3) YOKOYAMA: l. c. p. 16.

4) NATHORST: Om förekomsten af *Dictyophyllum Nilssoni* BRONGN. sp. i. Kinas Kol-orando bildningar. (By review.)

5) SCHENK: Pflanzlich Versteinerungen (RICHTHOFEN's China IV.).—Die während der Reise des Grafen BELA SZECHENYI in China gesammelten fossilen Pflanzen.

6) ZEILLER: Remarques sur la Flora Fossile de l'Altai, à propos des dernières découvertes Paléobotanique de M.M. les Drs. Bodenbender et Kurtz dans le république Argentine.

SCHMALHAUSEN,¹⁾ NEWBERRY²⁾ and BRONGNIART³⁾ have described many Jurassic and Rhaetic plants but there is relatively little resemblance between these and the Korean flora. The identical or closely allied forms are restricted to those fern types of a very wide vertical and horizontal distribution. Among the Mesozoic plants, now in Prof. YOKOYAMA'S possession, brought from various parts of Northern and Southern China, there are also no particular forms which indicate the presence of a close floral relationship with the Korean fossils.

The Oroville flora⁴⁾ of California is the best known of the Mesozoic vegetations in the Pacific border of North America. It is assigned to the Oolitic age. The predominance of *Pterophyllum*, *Ctenis* and *Ctenophyllum* constitutes a peculiar feature more or less like that of the Jurassic flora of India. But between this North American and the Japanese Tetori floras, there is only a slight resemblance though they are nearly contemporaneous; the distinction between the former and the Korean flora is more striking, apparently none of the species being either allied or identical. If what FONTAINE calls *Pinus Nordenskjoldi* is really identical with the plant so named from Korea, then it is the only species which shows any relation between the two floras.

In some respects, the Jurassic flora of India, seems to be more closely related to the Korean. There is in common the important species, *Dictyozamites falcatus*, above alluded to. It is

1) SCHMALHAUSEN: Pflanzen aus der nordwestlichen Mongolei.

2) NEWBERRY: Notes on Some Fossil Plants from Northern China. Description of Fossil Plants from the Chinese Coal-bearing Rocks in R. PUMPELLY'S Geological Researches in China, Mongolia and Japan.

3) BRONGNIART: Note sur les Plantes fossiles de Tinkiaiko envoyes en 1875 par M. l'Abbl. A. David.

4) WARD: Status of the Mesozoic Floras of the United States. The Older Mesozoic. P. 340.

very noteworthy, however, that the species is absent in the Oolitic flora of Kach, though common in the older Rajmahal group.

On the whole, so far as evidence goes, the writer has little hesitation in announcing the *contemporaneity of the Nakdong flora of Korea with that of the Japanese Totori series, the affinity of the former to those of the corresponding age in Siberia, China, India and California being apparently more distant.*

Nature of the plant-bed of Nakdong:—Next the question arises whether the plant bed is a fresh water deposit or not. In this connection, the following facts must be taken into consideration.

1) There are very few animal remains; a very incomplete bivalve and few Foraminifera with perforated calcareous shells were found in the same deposit.

2) There is no trace of marine plants.

3) Plant impressions of a more or less large size are generally arranged in the plane of stratification, often heaped one upon another.

4) In some parts, however, only crumbled pieces of plants are accumulated.

From the above facts, it is to be inferred that the deposition took place at least not far from the sea coast and there is a probability that the deposit was a beach formation in very shallow brackish water.



**Glossary of Korean Geographical Names Found
in the Text.¹**

An-eui.	安 義	Mun-gyöng.	聞 慶
Chhyön-san.	青 山	Na-jyu.	羅 州
Chhyüung-chhyong-Do.	忠 清 道	Nak-tong.	洛 東
Chhyu-phung-nyöng.	秋 風 岑	Nak-tong-gang.	洛 東 江
Chin-an.	鎮 安	Nam-phyöng.	南 平
Chin-hai.	鎮 海	Nam-uön.	南 原
Chin-jyu.	晉 州	Ok-chhyön.	沃 川
Chyan-syöng.	長 城	Ok-ka.	王 果
Chyol-la-Do.	全 羅 道	Phyöng-yang.	平 壤
Chyöng-jyu.	全 州	Po-cun.	報 恩
Fusan (Pu-san).	釜 山	Pul-tang-kokai.	佛 堂 峴
Hai-nam.	海 南	Pu-sang.	扶 桑
Ham-chhyang.	咸 昌	Sa-chhyon.	泗 川
Hoang-gan.	黃 澗	Söul.	京 城
Im-sil.	任 實	Syan-jyu.	尙 州
In-chhyön.	仁 川	Syong-ni-san.	俗 離 山
Keum-chhyön.	金 泉	Tol-pa.	石 田
Keum-san.	錦 山	Tong-pok.	同 福
Koang-jyu.	光 州	Tu-man-gang.	豆 滿 江
Ku-ryoi.	求 禮	Yong-am.	靈 岩
Kyöng-syang-Do.	慶 尙 道	Yong-dam.	龍 潭
Masampho.	馬 山 浦	Yong-dong.	永 同
Mokpho.	木 浦	Yong-il.	迎 日
Mu-jyu.	茂 朱	Yuk-sim-nyöng.	六 十 岑

1) KOTÖ and KANAZAWA: A Catalogue of the Romanized Geographical Name of Korea. 1903.

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MESOZOIC PLANTS FROM KOREA

PLATE I.

Plate I.

(All the figures are in natural size.)

Adiantites Sewardi sp. nov. P. 39.

Figs. 1-7. Specimens from Korea.

Fig. 8. A better specimen from Kami-uchinami, Onogori, prov. Echizen in Japan.

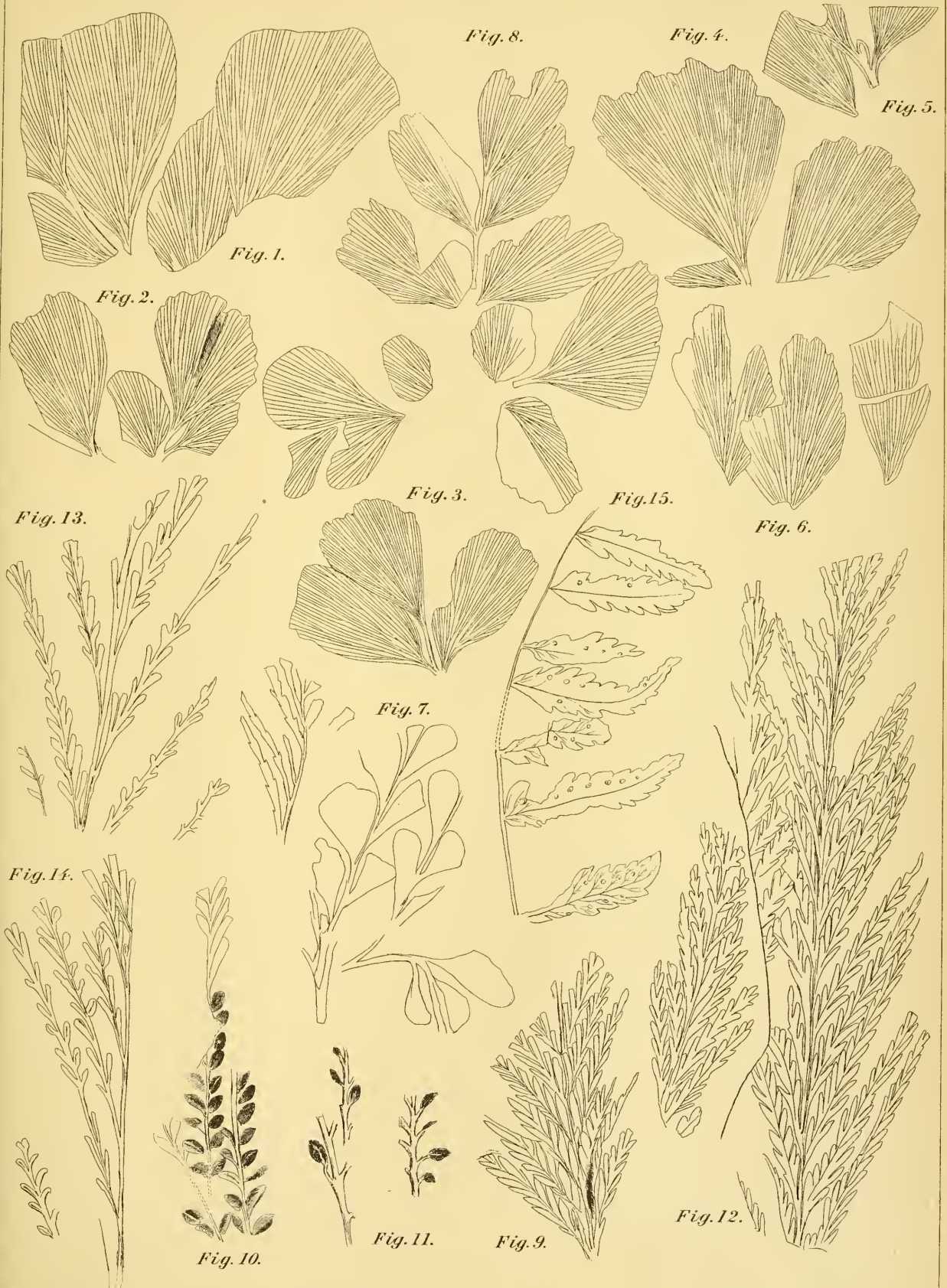
Onychiopsis elongata (Geyler). P. 22.

Figs. 9-11. Specimens from Korea ; fig. 9 is a sterile pinna, while the others are fertile ones.

Figs. 12-14. Specimens from Japan ; fig. 12 shows a specimen from Kami-uchinami, Onogori, which was referred by Mr. MATSUSHIMA to *Sphenopteris Mantelli* ; and figs. 13 and 14 are fertile ones from Shimamura, prov. Kaga.

Sphenopteris sp. P. 38.

Fig. 15. A fertile pinna.



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MESOZOIC PLANTS FROM KOREA.

PLATE II.

Plate II.

(All the figures are in natural size.)

Cladophlebis koraiensis sp. nov. P. 32.

Fig. 1. A sterile frond.

Dictyozamites falcatus (MORRIS). P. 11.

Figs. 2-4. All pinnae show the reticulated venation, though not represented on the figures.

Fig. 5. A pinna, figured specially to show the venation.

Figs. 6-7. Two detached pinnae shorter and broader than others.

Coniopteris hymenophylloides BRONGN. ? P. 29.

Fig. 8. A fertile pinna.

Pinus sp. P. 18.

Fig. 9. *P.* cfr. *Nordenskjoldi* HR.

Fig. 10. *P.* cfr. *prodromus* HR.



Fig. 1.

Fig. 2.

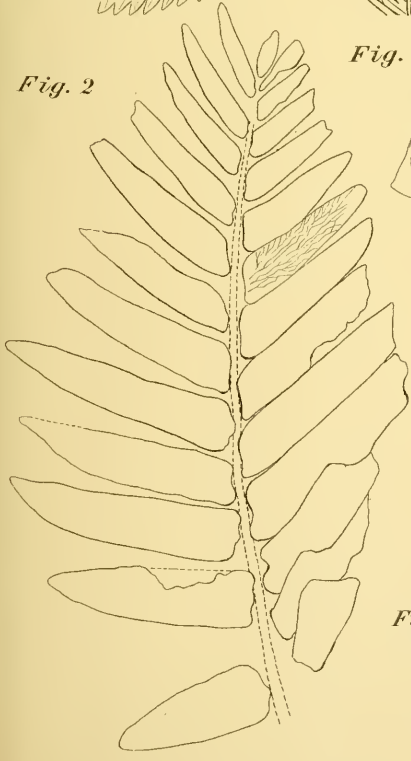


Fig. 7.



Fig. 3.

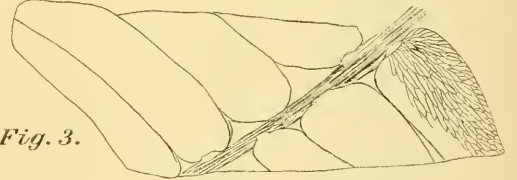


Fig. 5.



Fig. 10.

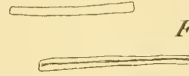


Fig. 9.



Fig. 8.



Fig. 6.



Fig. 4.



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MESOZOIC PLANTS FROM KOREA.

PLATE III.

Plate III.

(All the figures, except fig. 14, are in natural size.)

Nilssonia orientalis HR. P. 13.

Figs. 1-5.

Nilssonsia sp. P. 14.

Fig. 6.

Dioonites (?) sp. P. 14.

Fig. 7.

Coniopteris hymenophylloides BRONGN. ? P. 29.

Fig. 8.

Coniopteris Heerianus (YOK.) P. 27.

Fig. 9. A fertile pinna.

Fig. 4. A pinnule, magnified two diameters.

Equisetum ushimarensense YOK. P. 43.

Fig. 10.

Cladophlebis cfr. *denticulata* BRONGN. P. 32.

Fig. 11.

Cladophlebis koraiensis sp. nov. P. 32.

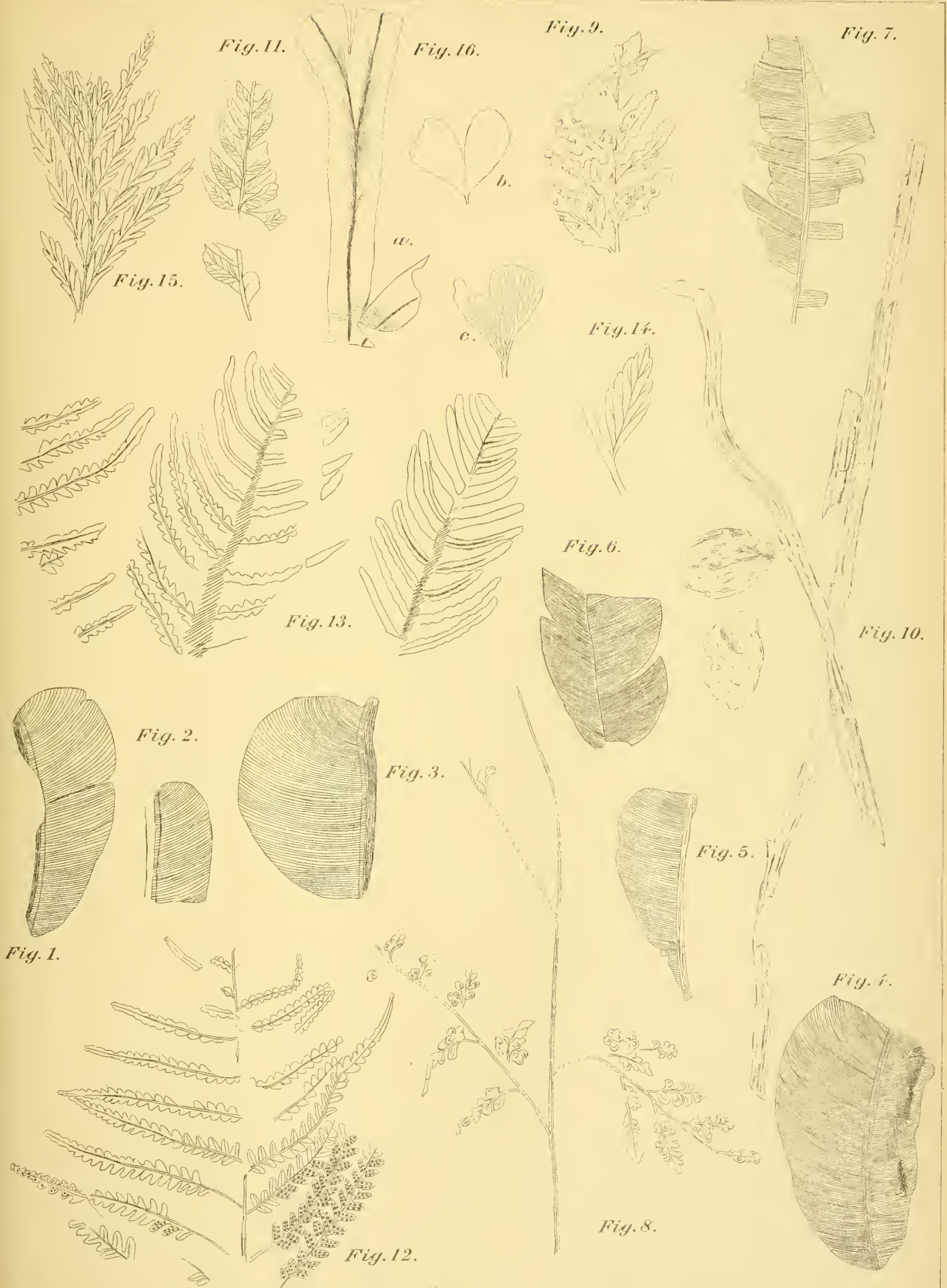
Figs. 12-13. Both represent the fertile pinnae; on fig. 13, the round dots are omitted.

Onychiopsis elongata (GEYLER). P. 22.

Fig. 15.

Sagenopteris bilobata sp. nov. P. 41.

Fig. 16. a, var. *major*; b, c, var. *cuneata*.



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MESOZOIC PLANTS FROM KOREA.

PLATE IV.

Plate IV.

(All the figures are in natural size.)

Podozamites lanceolatus (LINDL. and HUTTON). P. 17.

Figs. 1-5.

Podozamites Rheinii GEYLER. P. 16.

Fig. 6.

Otenophyllum (?) sp. P. 17.

Fig. 7.

Cladophlebis sp. P. 37.

Fig. 8.

Cladophlebis cfr. *Dunkeri* (SCHIMPER). P. 37.

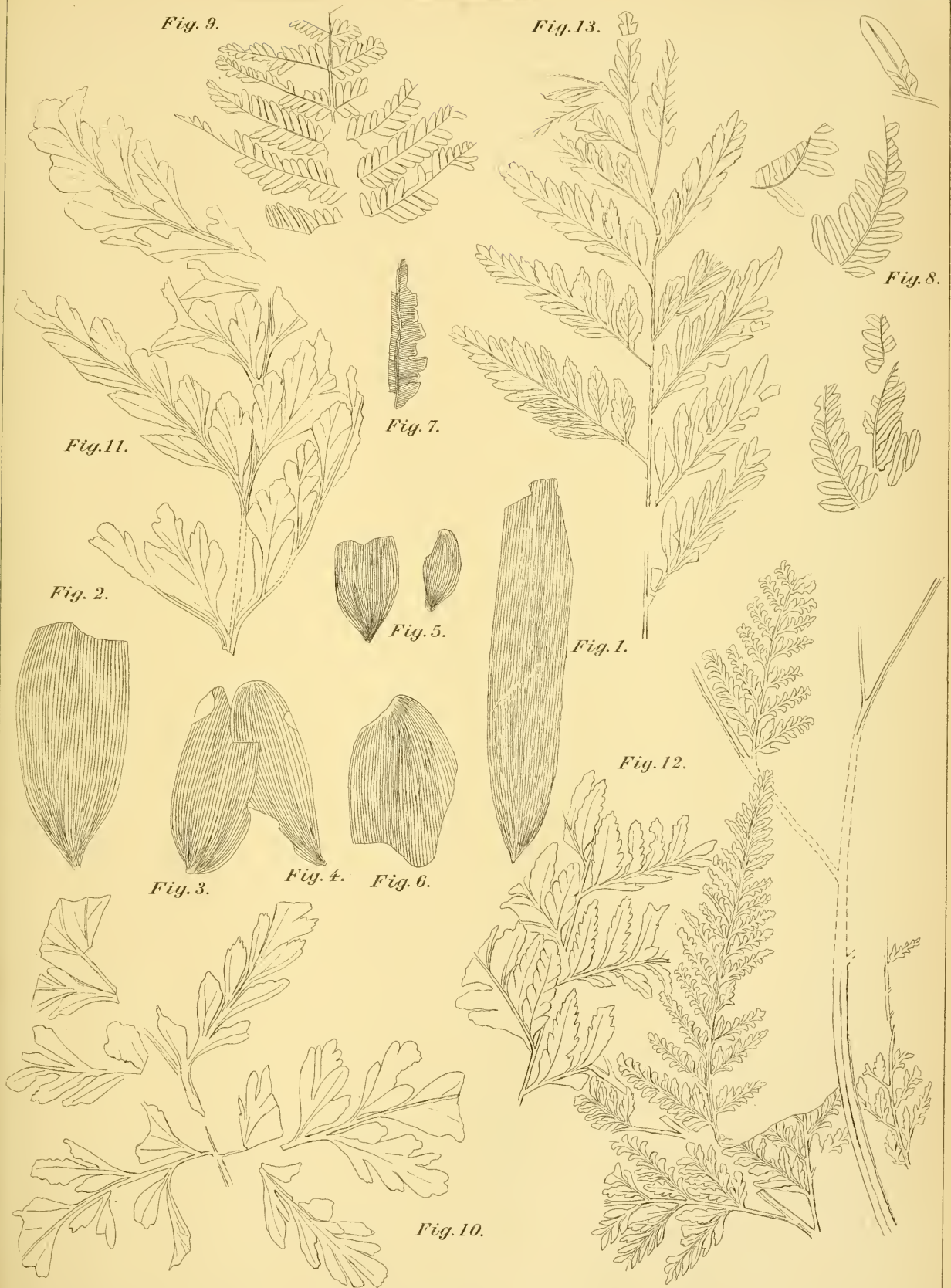
Fig. 9.

Sphenopteris nakdongensis sp. nov. P. 38.

Figs. 10-11.

Coniopteris sp. P. 26.

Fig. 12. A specimen with fertile pinnac, from Shimamura, prov.
Kaga in Japan.



Modulus of Elasticity of Rocks*

AND

SOME INFERENCES RELATING TO SEISMOLOGY.

By

S. Kusakabe, *Rigakushi*.

With two plates.

CONTENTS.

- I. Introduction.
- II. Arrangement and Flexure-apparatus.
- III. Process of Observation and Calculation.
- IV. Experimental Results.
- V. Some Inferences relating to Seismology.

INTRODUCTION.

The present experiments, detailed descriptions of which are to be found in "The Publications of the Earthquake Investigation Committee in Foreign Languages" No. 17, Tokyo, 1904, serve as a complement to the note, recently published by the

* A short abstract is to be found in the "Proceedings of the Tokyo Physico-Mathematical Society" Vol. II., No. 11. May, 1904.

author, on the modulus of rigidity of rocks.* Some of the specimens were identical with those used in the last investigation, and the others were prepared in a similar manner. The principal object of the present investigation is not to determine any accurate value of the modulus of elasticity, but to determine whether the modulus is constant within tolerably wide limits or not, and if it is not constant, how it varies with the amount of stress or with time and other factors which affect the change. The modulus is measured by the method of flexure; but the apparatus is more complex than the one which is generally employed. It may therefore not be superfluous to give the following detailed description of it.

ARRANGEMENTS AND FLEXURE-APPARATUS.

In the measurement of flexure, the use of the cathetometre or of the micrometrescrew are generally dispensed with. The method with mirror and scale, as modified by A. KÖNIG,† is generally adopted, though that by optical interference is more accurate. The apparatus as designed in the present experiment combines the advantages of KÖNIG's arrangement with other necessary appliances. The principal improvements are:—(1) the bending of the specimen cyclically from one side to the other, with increasing and decreasing force passing through zero continuously; (2) the elimination of external disturbances such as any minute rotation of the specimen or slight displacements of the scale and telescope.

* Ibid. Vol. I., No. 14, Oct. 1902. Pub. of the E. I. C. in F. L. No. 14, Tokyo, 1903. The Journal of the College of Science, Imperial University of Tokyo. Vol. XIX., Art. 6. 1903.

† A. KÖNIG. Ueber eine neue Methode zur Bestimmung des Elasticitätsmoduls. Wied. Ann. 28, 1886.

A rough sketch of the arrangement is shown in Fig. 1. The specimen is placed horizontally and, when it is bent, its plane of curvature is also horizontal. There are necessarily one scale, four fulcrums and four mirrors, of which two mirrors M_1 and M_2 are attached to the specimen as in KÖNIG'S method, while the others M_3 and M_4 are rigidly fixed to the support. Four different images of one and the same scale S are to be seen in the field of the telescope T , Fig. 2. They are all reflected twice by the following mirrors respectively :—

Right upper image	reflected by the mirrors	M_1 and M_2 ,
right lower	„ „ „ „	M_1 and M_4 ,
left upper	„ „ „ „	M_3 and M_2 ,
left lower	„ „ „ „	M_3 and M_4 .

The apparatus is shewn in Figs. 3, 4 and 5, in its front- and side-views as well as in its plan. The two mirrors M_1 and M_2 rotate as the specimen is bent, while the other mirrors M_3 and M_4 are fixed unless the apparatus itself is displaced. The fulcrums F_1 , F_2 , F_3 and F_4 are so adjusted that the edges of any two of them lie in a vertical plane. A small framework F , which is shown in Fig. 6, serves to apply bending force to the specimen. The frame-work consists of two wedges, one fixed (W_1) and the other movable (W_2) inside a proper case. After placing a proper specimen between the two wedges, the movable wedge W_2 may be pushed firmly against the specimen by the fixed screw S . At the extremities of the strings S_1 and S_2 , which run over small pulleys P_1 , P_2 etc. towards the observer, some weights are hung which supply the bending force. The support of the fulcrums is made of soft iron, which is rigidly screwed on a wooden block.

From what has been just described, it may be easily seen that, when equal weights are hung on both S_1 and S_2 , no bending

force is exerted on the specimen, and that it is only the difference of the weights attached to the two strings which is effective in bending it. That is to say, if m_1 and m_2 are the two weights attached to the strings S_1 and S_2 respectively, then their sum $m_1 + m_2 = M_0$ registers the action of the bending force, the last of which is due to their difference $m_2 - m_1 = M$. For future reference, M_0 and M will be called the *resisting mass* and the *effective mass* respectively.

When the effective mass is positive, the specimen is supported by the fulcrums F_3 and F_4 , and it becomes convex towards the righthand side. In the other case, it becomes convex towards the lefthand side, supported by the fulcrums F_1 and F_2 . The fulcrums standing face to face, i.e. F_1 and F_3 or F_2 and F_4 , are clamped so as not to push too tightly against the specimen, as there is a possibility that the bending of the specimen will be hindered by friction.

A telescope, provided with a micrometer-screw, is rigidly clamped on a tripod. The scale, engraved on a ground-glass plate, 20 cm. long and 2 cm. wide is covered with a black board having a slit, 8 mm. wide, and is illuminated by a row of small gas jets.

PROCESS OF OBSERVATION AND CALCULATION.

The observation is generally as follows:—

1. To begin with, equal weights, each $\frac{1}{2} M_0$, are hung on the strings S_1 and S_2 .
2. A specimen is put between the fulcrums, passing through the frame-work F , the last of which is to be clamped on the

middle part of the specimen. The planes passing through the edges of the fulcrums standing face to face should be normal to the length of the specimen.

3. The four mirrors are so clamped in their proper positions that the images of the scale reflected by them stand side by side within the telescope-field. To adjust them properly requires much practice.

4. The constants of the micrometer-screw for all images are determined. They are nearly equal to each other but not strictly so. One mm. of the scale division is equal to about 23 divisions of the micrometer-screw, which is again equivalent to a rotation of 5.176×10^{-6} rad. i.e. $1''.068$.

5. Zero-readings are taken for all images in a fixed order ; i.e. (i) right upper image, (ii) right lower image, (iii) left upper image, (iv) left lower image.

6. The suspended weights consist of some forty pieces of equal weight. A definite number of pieces, say $\frac{1}{2} m.$, are taken off from one string and added on the other. The bending force due to this is obviously mg , where g represent the value of gravity. The time-record corresponding to this transposition of weights is taken.

7. After a certain time, the readings are noted for all images in the same order as in the case of the zero-reading.

8. Second transposition of weights ; the time recorded ; scale-readings noted : and so on till a definite amount of bending force is reached.

9. The weight is then transposed in the opposite way so that the force diminishes gradually and ultimately becomes oppositely directed. In this way, a series of observations is made to complete the cyclic process several times.

10. From the amount of the deviations of the images, the amount of bending due to each corresponding force is calculated, by the following method.

In Fig. 7, let the zero-reading be taken when the telescope is in T while the mirrors M_1 and M_3 are in the position Mm_1 and the mirrors M_2 and M_4 in the position $M'm_2$. In reality, the reflections of light by the mirrors take place, as a matter of course, in the space of three dimensions; but, for the sake of simplicity, let us assume that the path of the ray of light lies wholly on the plane of the paper. Let ab be the position of the scale, and suppose that a is a point which gives its images in the field of the telescope after reflecting at s and s' . Suppose that, after a certain number of operations, the specimen is bent, it is rotated and also the telescope is displaced and rotated relatively to the scale. Let their respective values be given by

α =angle through which the mirror M_2
is rotated as the specimen is bent,
 $-\alpha$ =angle through which the mirror M_1
is rotated as the specimen is bent,
 β =angle through which the specimen is rotated,
 δ =the component of the displacement of
the telescope parallel to the scale.

Note that the other component is negligible relatively to the distance between the scale and the telescope.

γ =the amount of rotation of the telescope.

Then, if θ and ω denote the angles between the mirrors M_2 and M_4 , M_1 and M_3 respectively, we have

TABLE I.

Specimen convex to:	Righthand side.		Lefthand side.	
Rotation of the specimen.	Clockwise.	Counter-clockwise.	Clockwise.	Counter-clockwise.
θ	$a - \beta$	$a + \beta$	$-a + \beta$	$-a - \beta$
ω	$-a - \beta$	$-a + \beta$	$a + \beta$	$a - \beta$

That is to say, provided a and β are taken as algebraic quantities having proper signs, we have simply

$$\theta = a + \beta$$

$$\omega = \beta - a$$

Let r' be the last position of the telescope, and put

R.U.=The deviation of the right upper image,

R.L.= „ „ „ „ right lower image,

L.U.= „ „ „ „ left upper image,

L.L.= „ „ „ „ left lower image.

Then, from simple geometry, it may be easily proved that

$$L.L. = \delta + (D + c + d)\gamma,$$

$$L.U. = \delta + (D + c + d)\gamma - 2d\omega,$$

$$R.L. = \delta + (D + c + d)\gamma + 2(c + d)\theta,$$

$$R.U. = \delta + (D + c + d)\gamma - 2d\omega + 2(c + d)\theta,$$

where $ss' = c$, $sa = d$, $ts' = D$.

If there is no external disturbance, evidently we have

$$\beta = 0 \quad , \quad \gamma = 0 \quad , \quad \delta = 0,$$

so that

$$L.L. = 0$$

$$L.U. = 2da,$$

$$R.L. = 2(c + d)a,$$

$$R.U. = 2(c + d)a + 2da,$$

$$= 4\left\{d + \frac{c}{2}\right\}a,$$

the last of which is a well known form.

In all cases, we have between the four values the following functional relation.

$$L.L. + R.U. = R.L. + L.U.$$

Thus, the difference of the two sums indicates an error of observation: whence it gives the means of rejecting from numerous observations those which are incorrect. For instance, in the case of a piece of sandstone we had:

TABLE II.

M.	R.U.	R.L.	L.U.	L.L.	R.U. + L.L.	R.L. + L.U.	Error.
900 ^g	1 ^c .129	0 ^c .529	0 ^c .593	−0 ^c .004	1 ^c .125	1 ^c .122	0 ^c .003
1200	1.670	0.789	0.877	−0.006	1.664	1.666	−0.002
1500	2.204	1.039	1.159	−0.007	2.197	2.198	−0.001

To calculate the amount of bending, we have four equations containing four unknown quantities. There is, however, one functional relation between the four equations. At the same time, the unknown quantities also may be reduced to three, as δ and γ appear always in one and the same combination.

Put $x = L.L.$
 $x + y = L.U.$
 $x + z = R.L.$
 then $x + y + z = R.U.$

Taking any three of the four equations, we may solve them. It is preferable, however, to use all equations, since none of them is strictly correct. Applying the method of least squares we have

$$x = \frac{1}{4}[3L.L. + L.U. + R.L. - R.U.],$$

$$\begin{aligned}
y &= \frac{1}{2}[(L.U. + R.U.) - (L.L. + R.L.)], \\
z &= \frac{1}{2}[(R.L. + R.U.) - (L.L. + L.U.)], \\
\text{where } x &= \partial + (c + d + D)\gamma, \\
y &= -2d\omega, \\
z &= 2(c + d)\theta, \\
\text{and } \theta &= \alpha + \beta \\
\omega &= \beta - \alpha.
\end{aligned}$$

Eliminating x , y , z , θ and ω from the above equations, we have

$$\begin{aligned}
\alpha &= \frac{1}{3} \frac{c + 2d}{d(c + d)} \left\{ (R.U. - L.L.) + (L.U. - R.L.) \frac{c}{c + 2d} \right\}, \\
\beta &= \frac{1}{3} \frac{c + 2d}{d(c + d)} \left\{ (R.L. - L.U.) + (L.L. - R.U.) \frac{c}{c + 2d} \right\}.
\end{aligned}$$

In the example above cited, we have

TABLE III.

$c = 12.4 \text{ cm.} \quad d = 241.5 \text{ cm.} \quad \frac{c}{c + 2d} = 2.503 \times 10^{-2}, \quad \frac{1}{3} \frac{c + 2d}{d(c + d)} = 1.0099 \times 10^{-3}.$				
M.	R.U. - L.L.	R.L. - L.U.	α	β
900 ^g	1.133	-0.064	$11.46 \times 10^{-4} \text{ rad.}$	$-0.93 \times 10^{-4} \text{ rad.}$
1200	1.676	-0.088	16.95	-1.31
1500	2.211	-0.120	22.36	-1.76

It is to be noticed that, in the above calculation, the tangent and arc of an angle are taken to be equal to each other. The greatest angle to be dealt with is of the order of 10^{-2} radian: whence the difference between the tangent and the arc is of the order 10^{-6} , that is to say, it is of the order of 10^{-4} of their own amounts, which is within the error of observation.

The relation between the modulus of elasticity and the amount of bending is given by the well known formula.

$$E = \frac{3}{4} \frac{Mgl^2}{ab^3a}$$

where a and b are the breadth and thickness of the specimen, while l is the distance between the corresponding fulcrums.

EXPERIMENTAL RESULTS.

The last investigation with regard to the modulus of rigidity proved a great deviation from Hooke's law even in the case of the least strain. Preliminary experiments showed it to be the same also in the case of bending. Looking at the curve in Fig. 8, we see that there is a tendency on the part of the rock to persist in any strained state which it may have acquired, especially when the variation of the stress changes its sign. The curve is closed and it is also of simple and regular form, though its path during the increase of stress differs entirely from that during the decrease. All rocks, so far as the author has investigated, have this property in common, though they differ in the character of the curves and in other minute details.

It may be suspected that, as the resisting mass increases with the total mass to be moved, this may have some influence upon the hysteresis curve. The comparison of the results of four successive experiments, in which the resisting mass was 1000, 1300, 1600 and 1900 grams respectively, while all other conditions remained the same throughout, showed that the influence of the resisting mass might be safely neglected.

There is one important fact which deserves to be mentioned here. Although the hysteresis curve is of a definite form and

traces one and the same curve when a specimen is bent and unbent many times cyclically, the direction of the elongation of the curve does not remain fixed when the amplitude of the cycle—i.e. the greatest amount of stress applied to the specimen during the cycle—is varied. As a general rule, the hysteresis curve becomes more and more vertical when the amplitude of the cycle is further and further increased. One instance is given in Fig. 9.

The amount of hysteresis, which is to be measured by the area enclosed by the curve or by some function of it, is least for Archæan rocks and increases rapidly for new rocks.

Although the modulus of elasticity is never constant during a cyclical strain, its variation obeys one and the same law for both the on- and the off-curve, in so far as the centre of the cycle coincides with the neutral state of the specimen. It may be necessary to make a remark on the meaning of the term “Modulus of Elasticity.” As there is a great amount of hysteresis in the relation of stress to strain, the ordinary conception of the modulus of elasticity is ultimately vague and uncertain. The actual resistance to the deformation in any state whatever, be it already bent or twisted, elastic or plastic in that state, will be taken as the measure of elasticity in that state, so that in the present experiment, the modulus is measured, step by step, by the increase of bending per 200 grams increase of the effective mass.

The curve expressing the relation between the modulus of elasticity and the amount of strain is symmetrical with respect to the axis of ordinate. One instance for Limestone No. 29, is given in Fig. 10. Each kind of rock seems to have its own special character. If Hooke's law were to hold good, four branches of curve, of which the right and left branches correspond to the

cases where the specimen is bent convex righthand or lefthand side respectively, while the lower branches correspond to the increasing stress and the upper to the decreasing one, would all shrink to a single horizontal straight line. In the case where no hysteresis exists, both the upper and the lower branches would coincide with each other to make a line not necessarily straight.

For all cases of rocks here experimented upon, the upper branch is concave towards the positive axis of the ordinate. As to its character, however, the variety is very abundant: circular, hyperbolic, oval and other curves of higher order of complexity. The curvature of the lower branches is turned sometimes upwards and at other times downwards. Although it is not easy to determine any law according to which the modulus varies with the phase of the cycle, we may find, as a first approximation, an empirical expression for each specimen. For instance, in the case of sandstone, we have.

$$\text{for the upper branch,} \quad y_1 = 0.243 + 0.92x^2$$

$$\text{for the lower branch,} \quad y_2 = 0.243 + 0.043x^2$$

where y and x represent $E \times 10^{-11}$ and the phase respectively. As a matter of fact, the constant term of y_1 is equal to that of y_2 , representing the modulus of elasticity at the state where no external force is acting.

In the following table, the constant term of the expression for every specimen is given as the modulus of elasticity of several rocks. It corresponds therefore to the value of the modulus of elasticity in the state when the bending force became zero, during which the specimen, whose section was about one centimeter square and the distance between the fulcrums was 10 centimeters, was bent cyclically on both sides by a force varying between

those due to $M = \pm 3000$ grams-weight. The value in any other state under different conditions must necessarily be different from those given in the table.

TABLE IV.

No.	Rock.	Locality.	Kind.	Density.	Mod. of elasticity.	Mean E.	Velocity of Long. Wave.
ARCHÆAN ROCKS.					$\times 10^{11}(\text{c.g.s.})$		$\frac{\text{Km.}}{\text{Sec.}}$
31 ₁ .	Quartzschist.	Chichibu.	Metamorphic.	2.67	10.48—7.07	8.78	5.73
46 ₁ .	"	Gunma.	"	2.62	8.41—8.40	8.41	5.67
8 ₁ .	Serpentine.	Chichibu.	Eruptive (altered).	2.72	7.73—7.21	7.47	5.24
40 ₁ .	Micaschist.	Ibaraki.	Metamorphic.	2.54	6.49—5.92	6.21	4.94
18 ₁ .	Chloriteschist.	Chichibu.	"	2.88	8.63—5.39	7.01	4.93
7 ₂ .	Peridotite.	Kuji.	Eruptive (altered).	2.61	6.73—5.83	6.28	4.91
26 ₁ .	Chloriteschist.	Chichibu.	Metamorphic.	2.82	7.03—6.29	6.66	4.86
22 ₁ .	Gabbro.	"	Eruptive.	2.71	6.21—5.57	5.89	4.66
24 ₁ .	Graphiteschist.	"	Metamorphic.	2.59	5.12—4.93	5.03	4.41
23 ₁ .	"	"	"	2.56	3.69—3.37	3.53	3.71
42 ₂ .	Micaschist.	Ibaraki.	"	2.63	1.29—1.16	1.23	2.16
PALÆOZOIC ROCKS.							
34 ₁ .	Adinoleslate.	Gunma.	Sedimentary.	2.64	10.99—10.23	10.61	6.34
12 ₂ .	Clayslate.	Aumi.	"	2.71	10.71—9.08	9.90	6.04
9 ₁ .	Granite.	Mikage.	Eruptive.	2.54	4.31—3.66	3.99	3.96
21 ₁ .	Limestone.	Chichibu.	Sedimentary (Metamorphosed).	2.64	4.14—3.65	3.90	3.84
6 ₃ .	Marble.	Kuji.	"	2.68	3.51—3.24	3.38	3.55
14 ₁ .	Red Schalstein.	Aumi.	Sedimentary.	2.43	3.09—2.39	2.74	3.36
32 ₁ .	Pyroxenite.	Gunma.	"	2.90	2.96—2.91	2.94	3.18
10 ₂ .	Granite.	Kagawa.	Eruptive.	2.57	2.30—2.10	2.20	2.93
29 ₁ .	Limestone.	Gunma.	Metamorphic.	2.66	2.06—1.92	1.99	2.74

No.	Rock.	Locality.	Kind.	Density.	Mod. of elasticity.	Mean E.	Velocity of Long. Wave.
TERTIARY ROCKS. $\times 10^{11}$ (c.g.s.)							$\frac{\text{Km.}}{\text{Sec.}}$
351.	Sandstone.	Chichibu.	Sedimentary.	2.47	3.55—3.51	3.53	3.78
50.	Two Pyroxene Andesite.	Mutsu.	Eruptive.	2.70	4.04 2.38	3.21	3.44
23.	Tuff.	Izu.	Sedimentary.	1.90	1.39—1.36	1.38	2.69
53.	Rhyolite.	Yechizen.	Eruptive.	2.40	0.90—0.77	0.84	1.87
43.	Sandstone.	Kii.	Sedimentary.	2.25	0.68—0.57	0.63	1.67
34.	"	Chōshi.	"	2.21	0.34—0.20	0.27	1.11
DILUVIUM ROCKS.							
172.	Andesite.	Gumma.	Eruptive.	2.63	4.36—4.31	4.34	4.06
16.	"	"	"	2.32	0.68—0.63	0.66	1.69

As the hysteresis curve becomes more and more vertical when the amplitude of the cycle increases further and further, the mean elasticity necessarily weakens when the amplitude of the strain increases. For instance, in a case of sandstone where the curves could all be represented by a series of parabolic expressions, the constant term of them was :—

TABLE V.

Amp. (in gramsweight.)	300	600	1200	1800	2400	3000
E. (c. g. s. $\times 10^{11}$).	0.65	0.46	0.33	0.27	0.21	0.15

Thus it is important to notice how the modulus of elasticity diminishes when the amplitude of the strain increases.

Here it will suffice to remark that, as in the case of the modulus of rigidity, the modulus of elasticity also is comparatively greater in a strained than in the neutral state.

The phenomenon of yielding, though it is not so enormous as in the case of torsion, is still sufficiently great to be dealt with. For a piece of sandstone, e.g., which was loaded with $M_0=3300$ and $M=3000$ gramsweight, the amount of bending increased, in the course of two and a half days, to, at least, more than three times its initial value. It is, indeed, questionable whether there is any limit to the yielding.

Also the amount of residual surviving the bending force does not remain constant, but recovers gradually and uninterruptedly. The amount of recovery, in the case of the above specimen just referred to, increased, in the course of about four days, by more than twice its initial value.

The yielding of specimens under a constant force having become comparatively small after a few days, the temperature-variation of the flexure may be clearly observed. The relation between temperature and bending for a piece of sandstone is given in Fig. 11. The curve, as a whole, expresses the simple proportionality between the two elements. We find, however, the amount of flexure has a minimum value in the neighbourhood of about 9°C . In the case of the rigidity-modulus, we had a result strictly analogous of this effect. It may be, however, the effect of moisture. To determine any general relation between elasticity and temperature requires further investigation by a special arrangement.

SOME INFERENCES RELATING TO SEISMOLOGY.

In the author's publications above cited, it was experimentally as well as theoretically explained that, in the case of distorsional waves, the velocity of propagation is a function of the amplitude

of the wave, as there exists more or less yielding in the rocks through which the waves propagate, and also that, in view of this inference, we do not see the necessity of assuming the path of the tremors to be different from that of the principal shocks. The present experiment relating to other modulus give, it seems to me, still stronger foundations to support the above view. We must not however forget that, it is unfortunately the common rule rather than the exception that a theory, however perfect it may be, does not explain all the facts connected with it and also that almost every phenomenon has more than a single cause, and this is particularly true in the case of earthquakes.

As the elastic constant varies during one cycle of bending and all values at different phases of the cycle equally play their parts in causing the vibratory motion, the apparent value of the elastic constant during one complete vibration must be the mean value of all the values at different phases. Now the mean elasticity for one complete cycle being distinctly greater than what is commonly adopted, the actual velocity of propagation for seismic waves must be correspondingly greater than those given in the above table, which are calculated by taking the square root of the elasticity-density ratio. In the case, e.g., of a piece of sandstone, the result of the experiment shows that the mean value is 3.67 times greater than the constant term. Whence we may infer that the actual velocity, in this case, would be probably twice the value given in the table.

Again, the velocity must necessarily diminish with an increase of the amplitude of the wave, since the elasticity diminishes in that case as explained above. From the example given there, we may deduce the following to show how the velocity changes with the amplitude.

TABLE VI.

Ratio of Amplitudes.	1	2	4	6	8	10
Ratio of Velocities.	2.08	1.75	1.48	1.34	1.18	1.00

Though the variation of the elastic constant due to temperature-rise is comparatively small, it can never be neglected in so far as the velocity of seismic waves is concerned, since the underground temperature rapidly rises with the increase of depth. Although the elastic constants increase from Cainozoic to Archæan rocks in a greater ratio than the density does, to attain the main stratum of Palæozoic rocks we must go deep down some ten kilometres, at least, and for a stratum of Archæan rocks, at least, thirty kilometres, where the underground temperature must be tolerably high. Any conclusive deductions should, however, be postponed until the more accurate observations on the change of the elastic constants due to temperature-rise, which are in course of preparation, shall have fully elucidated the relation between the elastic constants and the temperature.

As a matter of fact, there are scattered everywhere within the earth's crust veins and dikes of different kinds of old rocks, uplifted by geological disturbances, some of which run over many hundreds or thousands of kilometres. The velocity along such a vein or dike must necessarily be greater than that through any of the surrounding strata, so that the seismic waves mainly propagate through that region. As a consequence of the above result, if an observing station be situated near such a vein, not only will the number of earthquakes observed at the station be greater than those observed at any place in the vicinity, but the direction of the motion will not necessarily indicate the position of the

seismic centre. It is a matter of daily experience with us who live in an earthquake country located in the 'girdle of fire of the Pacific, that observers in some districts feel all shocks as if coming from one particular direction even when the seismic centre lies in an entirely different direction.

As another consequence, there may exist seismic shadows; or, in other words, seismic waves may be partially shielded by a vein or dike of old rocks. Earthquakes originating in one region may always be well observed in the station while those originating in another region may fail to be observed in the station. In Prof. F. ŌMORI's paper* we find a most interesting example to support the above consideration. Of the earthquakes which happened between Sept. 1889 and July 1886 in Central Japan, those whose origins were situated within certain boundaries were never felt in Tokyo, though the weaker ones of more distant origins were clearly felt there.

The frequency of earthquakes as related to the geological distribution of rocks will be fully discussed in a following paper under a special title.

In conclusion, I wish to express my great indebtedness to Mr. FUKUCHI for valuable information concerning the geological characters of the specimens. My best thanks are due to Professor H. NAGAOKA, under whose kind guidance I have carried out this experiment.



* F. ŌMORI. The Pub. of the E. I. C. in F. L. No. 11. 1902.

Fig. 1.

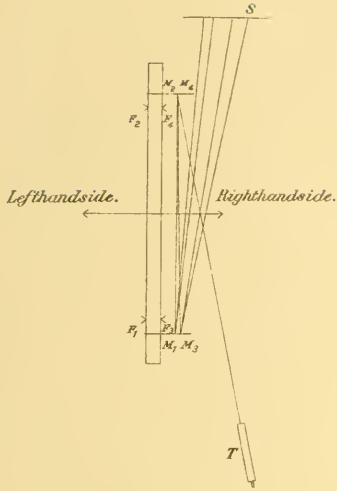


Fig. 2.

The field of telescope.

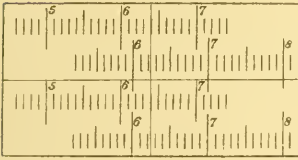


Fig. 6.

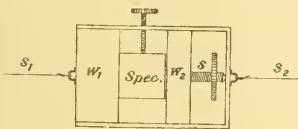


Fig. 3.

Front view.

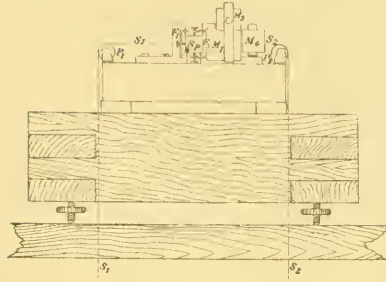


Fig. 4.

Side view.

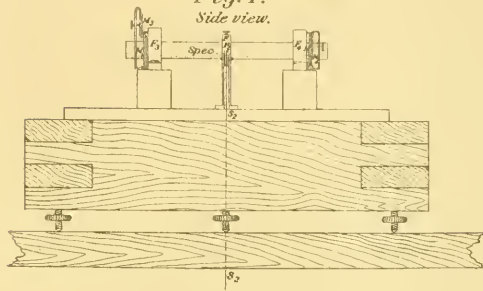


Fig. 5.

Plan of the flexure apparatus.

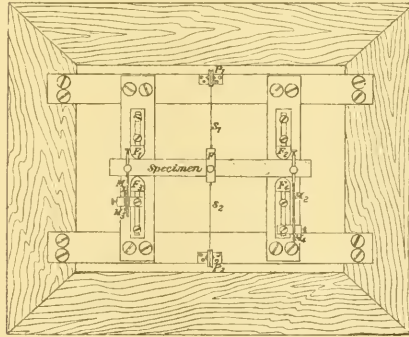


Fig. 11.

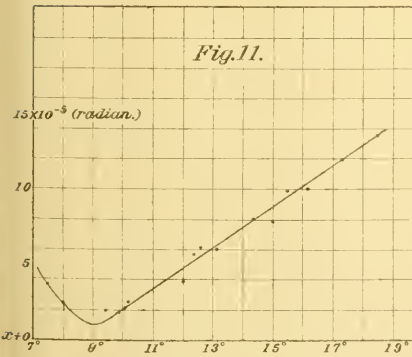


Fig. 10.

No. 29.
Limestone.

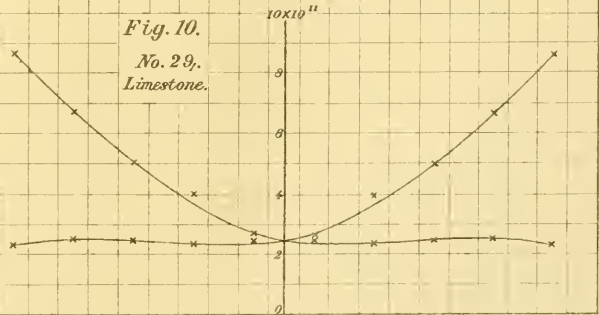
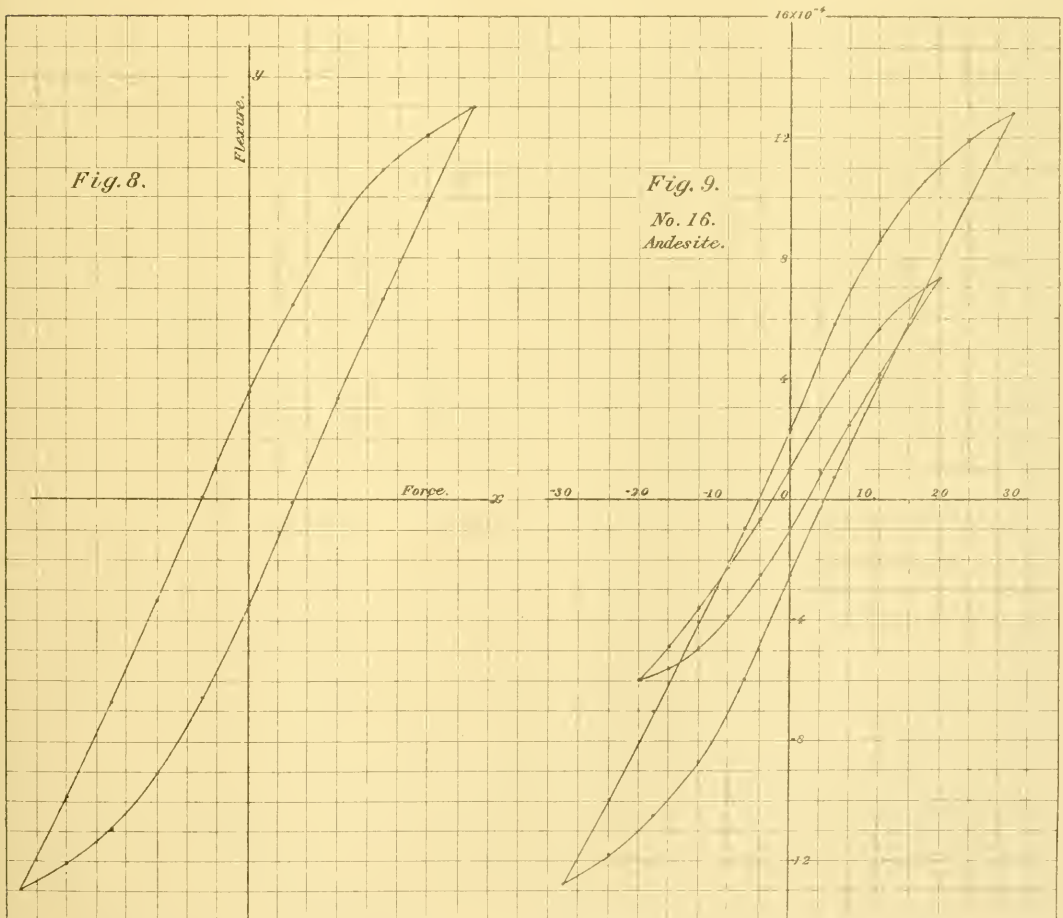
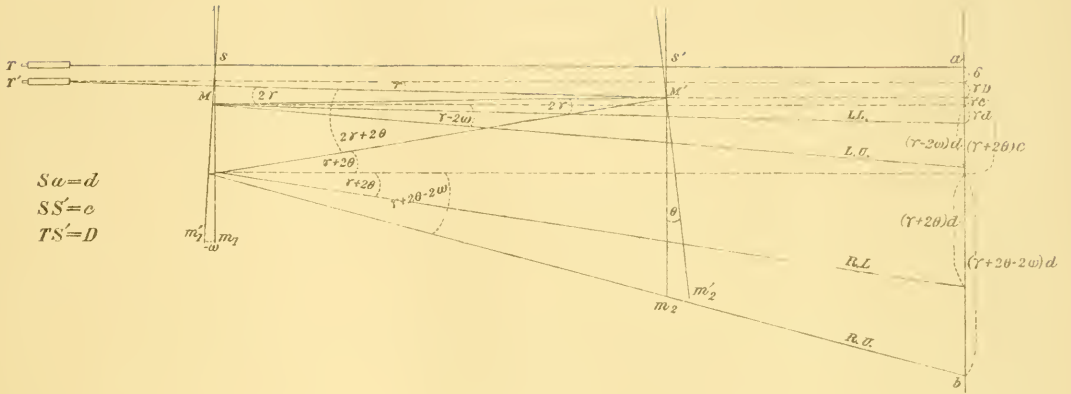


Fig. 7.



Kinetic Measurements of the Modulus of Elasticity

FOR

158 SPECIMENS OF ROCKS:

AND

A NOTE ON THE RELATION BETWEEN THE STATIC AND THE KINETIC VALUES
OF THE SAME.*

By

S. Kusakabe, *Rigakushi*.

With one plate.

CONTENTS.

- I. Introduction.
- II. Method of Measurement and Apparatus.
- III. Test of the Apparatus with a Tuning-fork and a Prism of Soft Iron.
- IV. Preliminary Experiments, and the Process of Calculation.
- V. Experimental Results.
- VI. Effect of Moisture.
- VII. A Note on the Relation between the Static and the Kinetic Values of the Modulus.

* The essence of this report was read in the meetings of the Tōkyō Physico-Mathematical Society for Sep. 1904 and April 1905 ; and was published in Nos. 15 and 22, Vol. II, Proc. of the Society.

I. INTRODUCTION.

As to the elastic constants of several rocks which compose the so-called outer-crust of our planet, we have already a valuable paper published by Professor H. NAGAOKA,* in which the elastic constants for one hundred specimens are given, with some notes relating to seismology. The author also has reported some experimental researches relating to the hysteresis and the variation of the constants under different conditions.† A little consideration, however, will make it evident that the values of elastic constants determined by a statical method may be far from what ought to be used in the discussion of seismic waves.

The importance of measuring them again by a kinetic method may thus be readily recognized. Not only are the rapid alterations of state concerned in the propagation of a wave attended with a thermal effect, which goes to change the elastic constants beyond their value statically obtained; but also in the case of rocks, the phenomenon of yielding may have great influence in making them deviate further from one another.

In the author's papers above cited it has been shown that the modulus of elasticity varies, during one cycle of strain, according to a definite law. When a piece of rock is bent by a force and unbent by virtue of its own elasticity, it is not, evidently, the modulus of elasticity at any particular state, which determines the vibratory motion of the rock. Moduli of elasticity at all the different phases of the vibratory motion equally take part in

* H. NAGAOKA. The Pub. of the E.I.C. in F.L. No. 4, 1900, and Phil. Mag. 1900.

† S. KUSAKABE. This Journal. Vol. XIX., Art. 6. and Vol. XX., Art. 9. The Pub. of the E.I.C. in F.L. Nos. 14 and 17.

causing the motion. Hence for the apparent modulus of elasticity during one complete vibration, we must take the mean value of the moduli at all different phases.

For a piece of sandstone, e.g., when the maximum bending force during the cycle was equal to that due to $M=3000$ grams-weight, we had a mean value 3.67 times greater than that taken at the state of no bending. In other words, the mean kinetic modulus for this specimen, provided the vibration be assumed to take place at as slow a rate as in this case, is nearly three and a half times greater than the static modulus.

Possibly sound-experiments furnish the best means of ascertaining the kinetic modulus of elasticity. The results deduced from such infinitely small strains as occur in sound vibration is no doubt of great significance as regards the elastic property of rocks. The fact that it seems strange to speak of the vibration of such loose rocks as sandstone, shows at once that the measurement of the kinetic modulus of elasticity in them is much more difficult than in metallic substances.

The method to be adopted here is a new application of Melde's experiment*, combined with the principle of resonance. The number of specimens examined amounts to one hundred and fifty eight, collected from various localities in the main islands of Japan, containing 23 Archæan, 65 Palæozoic, 12 Mesozoic and 58 Cainozoic rocks. This whole series of experiments is but a beginning in this field of inquiry and may be thrown aside as a wreck in the path of progress; yet the author hopes it may prove a help to later investigators.

* MELDE. *Phil. Mag.* Vol. 47, 1874. Lowery. *Ibidem.* Vol. 48, 1874.

II. METHOD OF MEASUREMENT AND APPARATUS.

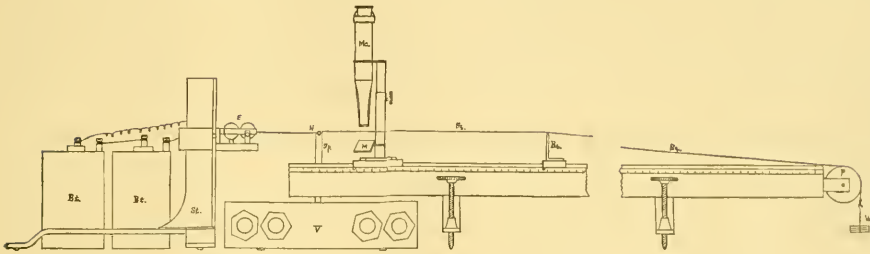
The essence of Melde's experiment is that, on one hand, a massive fork excited by a bow or sustained in permanent operation by an electro-magnet, produces its vibrations in approximate independence of the reactions of any light body, which may be connected with it; and, on the other hand, the period of the forced vibration of the light body is determined solely by the period of the force which is supposed to act on the system from without. The principle of resonance is merely that the kinetic energy or the amplitude of any forced vibration is the greatest possible, when the period of the external force is that in which the system would vibrate freely under the influence of its own elasticity.

The present method is simply as follows :—

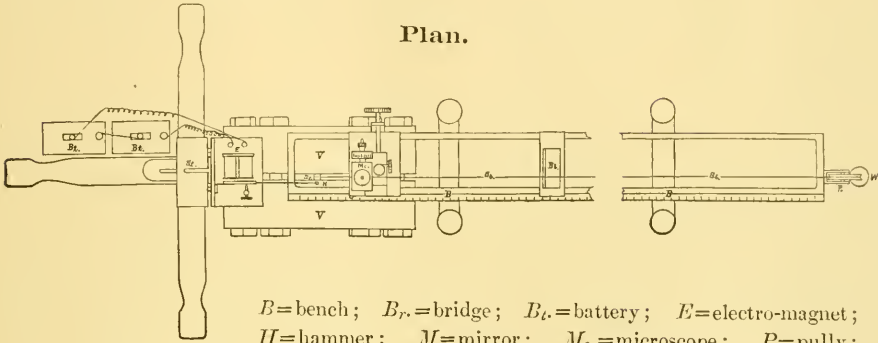
- a. A specimen of rock, one end of which is tightly clamped by a massive vice, is maintained in free vibration.
- b. A fine wire of known linear density w is connected with the free end of the specimen and stretched with a known tension.
- c. The length l of the above wire, in which the wire vibrates with maximum amplitude is measured.

The annexed figures show the plan and elevation of the whole arrangement, which is laid directly on stone floor of the laboratory.

Elevation.



Plan.



B = bench; *Br.* = bridge; *Bt.* = battery; *E* = electro-magnet;
H = hammer; *M* = mirror; *Mc.* = microscope; *P* = pulley;
Sp. = specimen; *Sr.* = string *i. e.* copper wire; *St.* = stand;
V = vice; *W* = weight.

A specimen *Sp.* clamped in the vice *V* is tapped by a hammer, *H*, which is supported by a stand *St.* and maintained in constant vibration electro-magnetically. A fine copper wire *Sr.* of ca. 0.05 mm. in radius is connected by means of bee's wax to the upper end of the specimen and stretched over a bridge *Br.* by a tension due to the suspended weight, *W*. The copper wire, whose breaking tension is ca. 140 grams, is strained by a tension of 100 grams during some tens of minutes. Both the bridge and the microscope *Mc.* may slide along an iron bench *B* of ca. 118 cm. in length, in which a scale is graduated for each mm.

The distinction of forced and free vibrations is very important, and must be clearly explained. If a vibration is the response of the system to a force imposed upon it from without

and is maintained by the continued operation of that force, it is obviously a forced vibration. It must, however, be remembered that any free vibration which we shall have in a laboratory experiment takes its origin necessarily from a force acting upon it from without. At first, there is a forced vibration not less important than its rival, but when the force is removed, though there is no discontinuity in velocity or displacement, yet the period of the force is at once exchanged for that natural to the system and the forced vibration is converted into a free vibration.

In the present case, the frequency of the hammer-blow, which is easily adjustable within wide limits by varying its moment of inertia, is about ten per second; while that of the vibration of the specimen lies between some three hundreds and a thousand per second. In other words, between two consecutiveappings, the number of vibrations of the specimen amounts to some thirty or one hundred, so that the mode of vibration is necessarily of a free nature.

III. TEST OF THE APPARATUS WITH A TUNING-FORK AND A PRISM OF SOFT IRON.

So far as the principle is concerned, the above statements are sufficient and nothing more is required. In laboratory work, however, there are several experimental difficulties to be overcome; especially, maintenance of the vibration and the fulfilment of the condition of a clamped end. The fixedness of the clamped end is absolutely important, since the frequency varies inversely as square of the length of the vibrating portion.

To test the apparatus, the experiment was made with a tuning-fork of known frequency, giving the following result.

Tuning-fork. Sol ₂ . 384 VS.					June 8, 1904.		
W=40.595 grs. $w=4.77 \times 10^{-4}$ grs./cm.					$g=979.8$ in the laboratory.		
Measured to	1st Obs.	2nd Obs.	3rd Obs.	4th Obs.	Mean.	l'	calculated.
I node.	24.0	24.1	24.1	24.0	24.0	24.00	24.0
II node.	47.7	48.4	48.0	47.6	47.9	23.95	47.8
III node.	71.6	71.6	71.4	71.4	71.5	23.83	71.6
IV node.	95.1	95.8	95.2	95.6	95.4	23.85	95.4

Here it is necessary to remark that, although the vibration of the string is due to the periodic force imparted from the specimen, the point of application of the force never corresponds to a loop, but, on the contrary, there is a node in that vicinity. Assuming the impressed force given by the vibrating rock, which is connected with the string at a point whose distance from the bridge is $x=b$, to vary as $F \cos pt$, the amplitude of the motion between the bridge and the rock is approximately given by

$$\gamma \left\{ \frac{\sin^2 \frac{px}{a} + \frac{f^2 x^2}{4a^2} \cos^2 \frac{px}{a}}{\sin^2 \frac{pb}{a} + \frac{f^2 b^2}{4a^2} \cos^2 \frac{pb}{a}} \right\}^{\frac{1}{2}}$$

where γ is the amplitude of the rock measured at the point where the string is connected, and f is the coefficient of friction of the string. From this expression it is evident that the amplitude of the forced vibration attains its maximum value when the point of application of the impressed force is a node.

In the above example, it is reasonable to assume that a nodal point lies somewhere at a point near the origin of the

scale-measurement. Let this distance be denoted by a , then the above values of l' correspond to $l + \frac{a}{N}$ where N is the number of loops contained in the observed segment of the string. Thus a and l being two unknown quantities, they may be easily calculated by the method of least squares. The result is:—

$$a = 0.24$$

$$l = 23.79.$$

The result of the second experiment with another string and smaller tension is

$$W = 20.908$$

$$w = 5.27 \times 10^{-4}$$

$$l = 16.32.$$

The number of free vibrations of gravest mode for a perfectly flexible string is given by

$$n_1 = \frac{1}{2l} \sqrt{\frac{Wg}{w}}$$

where W is the suspended weight to which the tension is due. But if we consider the string as not being infinitely thin, its stiffness must be taken into account. In the case where the extremity of the wire is constrained to be a node by stretching it over a bridge but no couple acts to fix its direction, the correction for a circular wire is given by

$$n_2 = \frac{\pi w^{\frac{3}{2}} E'}{16 l^3 \rho'^2 \sqrt{Wg}}.$$

where ρ' and E' are the specific density and the modulus of elasticity of the wire respectively.

Thus, the number of vibrations n of the specimen, which is identical with that of the connected wire, is given by

$$n = n_1 + n_2 = n_1 + \frac{\pi w E'}{32 \rho'^2} \frac{1}{n_1 l^4}$$

Another term of correction due to the effect of the wire being connected at the free end may be easily ascertained as we see that the effect of the small load dM is the same as a lengthening of the specimen, whose weight is M , in the ratio

$$M: M+dM.$$

Now, calculating the number of vibrations for the tuning-fork from the data above given, we have

$$n=191.9 \quad \text{from the first experiment,}$$

$$n=191.6 \quad ,, \quad ,, \quad \text{second} \quad ,, \quad .$$

The difference between each of these and the registered value 192 is within the error of observation.

As to the verification for the fulfilment of the condition of a clamped end, the case of a tuning-fork with two prongs is wholly out of place, so that it may not be superfluous to cite here the following observations with a prism of soft iron. Any continuation of the specimen beyond the clamped section would be without effect, as it acquires no motion; but as the first clamp is relaxed, the pitch rapidly falls, in consequence of the increase of the length. Hence, in tapping the specimen care must be taken to give no impact to the clamped section, i.e. the specimen should be tapped at a position corresponding to the centre of percussion with respect to the clamped section.

The result of the first observation is as follows :—(c.g.s. units).

$$\rho = 7.779$$

$$b = 0.763$$

$$L = 13.4$$

$$W = 30.718$$

$$w = 5.19 \times 10^{-4}$$

$$E' = 1.221 \times 10^{12}$$

$$\rho' = 8.667$$

$$g = 979.8$$

$$l = 10.87$$

whence

$$n_1 = 350.3$$

$$n_2 = 0.2$$

$$n = 350.5$$

The relation between the number of vibrations n and the modulus of elasticity E of the specimen is given by the well known formula

$$n = \frac{k}{2\pi L^2} m^2 \sqrt{\frac{E}{\rho}}$$

where k is the radius of gyration and ρ is the specific density of the specimen whose length is L ; while m is a constant satisfying the equation

$$\cos m \cosh m + 1 = 0.$$

The smallest root, 1.875, corresponds to the gravest mode of vibration. The first over-tone is ca. 2.6 octaves higher than the gravest tone, so that in an actual case the succeeding roots of the equation have no importance.

Now, calculating the modulus of elasticity for the specimen of soft iron from the above data, we have

$$E = 2.029 \times 10^{12} \text{ c.g.s. unit.}$$

In the above experiment, the direction of the motion of the specimen was perpendicular to the elongation of the string. It is well known that, if the direction of motion is parallel to the string, the period of the vibration of the string becomes double that of the specimen. That is to say, the frequency n of the specimen is equal to twice the frequency ($n_1 + n_2$) of the string. The second observation with another string and smaller tension was made under the last mode of vibration, giving the following result:—

$$W=11\cdot065$$

$$w=5\cdot67 \times 10^{-4}$$

$$l=12\cdot47$$

whence

$$n_1=175\cdot3$$

$$n_2=0\cdot2$$

$$n=351\cdot0$$

$$E=2\cdot034 \times 10^{12} \text{ c.g.s. unit.}$$

IV. PRELIMINARY EXPERIMENTS AND THE PROCESS OF CALCULATION.

Although the above testings gave satisfactory result, preliminary experiments with sandstone and tuff were so very ambiguous as to wholly confound the observer. At first sight, there seems to be no definite length with which the string may vibrate with maximum amplitude. In the case of sandstone, e.g., lengths corresponding to maximum amplitude were as follows:—

(1) 9·28	(1) 9·93	(1)10·64	(1)11·42	(1)12·34	(1)13·40	(1)14·63	(1)16·23
(2)17·39	(2)18·41	(2)19·69	(2)21·04	(2)22·61	(2)24·49	(3)26·06	(2)26·70
(3)27·58	(1)29·43*	(3)31·53	(2)32·53	(3)33·89	(4)34·62	(1)36·76*	etc. etc.

The small numbers in brackets are the number of loops contained in the segment. Those marked with * correspond to a peculiar mode of vibration.

It may be argued *prima facie* that the elasticity of such loose materials as rocks which compose the earthcrust is not unique and therefore, as the facts prove, that the velocity of the propagation of seismic waves is diverted between wide limits. If we assume that all these lengths equally correspond to the proper vibrations of the specimen, then the velocity of longitudinal waves

should be proportionally many-valued. In the case of sandstone No. 3₄, e.g. we have,

	$l =$	13.48	15.33	16.36	17.20	19.25	21.68	24.67	28.72	34.82	42.89
whence	$V \propto$	12.9	11.3	10.6	10.1	9.0	8.0	7.0	6.0	5.0	4.0

In Professor F. Ōmori's papers relating to seismometry we frequently find what correspond to the above, calculated as the velocities of seismic waves in their successive phases.

Repeated experiments, however, showed that this confusion was an effect of the tapping by the hammer, so that varying the period of the impressed force we might obtain another series of maximum values. Although the vibration is really of a free nature, it is rendered intermittent by the periodic interposition of an obstacle, so that a very different result is arrived at. In this case, a vibration of a frequency n varies in its amplitude with a frequency m , which last is the frequency of the hammer. The amplitude increases very suddenly and it is always positive so that the motion may be assumed, though by a very rough approximation, to be represented by the expression,

$$Y = A_0 \cos 2\pi nt + \sum_{v=1}^{v=\infty} A_v [\cos 2\pi (n + 2v m) + \cos 2\pi (n - 2v m)].$$

It is obvious that, in such a case as the above, the amplitude takes its maximum value when the length of the strings corresponds to any one of the numerous component vibrations. The relative magnitudes of the several maximum amplitudes differ very much from one another and in such a way that the greatest maximum corresponds to the vibration in the natural period of the specimen, and the smaller the amplitude the more it is affected by the impressed force.

When m is not too small to be compared with n , each maximum may be distinctly observed; but their consecutives more and more approach each other as the ratio m/n becomes

smaller and smaller. In the case where the ratio is one-fiftieth or smaller than that, the series of maxima become approximately continuous and practically constitute one maximum with a small gradient, as in the case of soft iron.

Again, varying the period of the impressed force from m to m' , all the lengths corresponding to maximum amplitudes, except that which corresponds to the natural period of the specimen, are changed. When these two facts are taken into account, it is not a difficult matter to determine the natural period of vibration for any specimen at hand.

Let l_α and l_β be the lengths of string, vibrating with one loop, corresponding to the number of vibrations $(n+2\alpha m)$ and $(n+2\beta m)$ respectively, then for a certain length l , which is a common multiple of l_α and l_β , the string vibrates in a peculiar manner apparently with one loop, nodes of one mode of vibration being over-lapped by loops of another mode and *vice versa*.

For example, in the case of sandstone, the result of one experiment with a brass hammer showed that the string might vibrate with a maximum amplitude corresponding to any one of the number of vibrations

$$410.0 \pm 25.7 \nu$$

where ν is an integer, so that we have

$$\begin{aligned} n &= 410.0 \\ 2m &= 25.7. \end{aligned}$$

Another experiment with a lead hammer, in which the moment of inertia was increased, gave a different result, as follows:—

$$\begin{aligned} n &= 409.3 \\ 2m' &= 15.3. \end{aligned}$$

These two values for the frequency in free vibration are equal to each other within the error of observation.

In the above observations, the tension of the string remained constant and equal to

$$W=30.718 \text{ grams.}$$

To test whether the error of observation is affected by the variation of the constant tension or not, two other observations were made on the same specimen, giving the result ;

$$W=30.718, \quad n=409.7$$

$$W=20.908, \quad n=411.4$$

$$W=11.065, \quad n=409.1$$

Now, taking the mean of the above values, the data required to calculate the modulus of elasticity of the sandstone are

$$L=9.9$$

$$b=1.16$$

$$\rho=2.25$$

$$n=410.1$$

whence

$$E_K=10.36 \times 10^{10} \text{ c.g.s. unit.}$$

It may be here noted that the value determined by the static method is nearly half of the above, i.e.

$$E_s=5.7 \times 10^{10} \text{ c.g.s. unit.}$$

So far as the principle is concerned, the present method is very simple, and it may be easily understood at a glance. The mode of observation and the process of calculation, however, are so tedious and complicated that the author considers it in no case superfluous to recapitulate them.

With a known tension $W=W_1$ and a linear density $w=w_1$ of the string and a certain frequency of the hammer $m=m_1$, we proceed as follows :—

Node. Obs.	1st	2nd	—	r th	—	q th
1st	l_{11}	l_{12}	—	l_{1r}	—	l_{1q}
2nd	l_{21}	l_{22}	—	l_{2r}	—	l_{2q}
3rd	l_{31}	l_{32}	—	l_{3r}	—	l_{3q}
Mean.	l'_1	l'_2	—	l'_r	—	l'_q
l'_r/r	l_1	l_2	—	l_r	—	l_q

Now, a and l_a being two unknown quantities, we have the relation

$$l_a + \frac{a}{r} = l_r \quad \text{where } r=1, 2, \dots, q.$$

By the method of least squares, l_a may be easily found and from it the frequency of the string n_a may be calculated by the formula given in the third chapter.

$$n_1 \quad n_2 \quad n_3 \quad \text{—} \quad n_v \quad \text{—} \quad n_{t-1} \quad n_t,$$

which are connected by the relation

$$n + 2m_1\nu = n_v \quad \text{where } \nu=1, 2, \dots, t.$$

From these values, the frequency of the free vibration of the specimen may be calculated by the method of least squares, n and m_1 being two unknown quantities. Thus we have the first value for the frequency, i.e.

$$n = n'.$$

Now, varying the tension, linear density of string and period of the hammer, i.e.

$$W = W_2, \quad w = w_2, \quad m = m_2$$

we proceed as in the former case and obtain a second value

$$n = n''.$$

A third series of observations, with $W = W_3$, $w = w_3$ and $m = m_3$, gives a third value

$$n = n'''.$$

These three values of the frequency, i.e. n' , n'' and n''' are nearly equal to one another provided there be no blunder or mistake in the observation or in the reduction of the result. Taking the mean of these three values as the frequency of the free vibration of the specimen, with a small correction due to the stiffness of the string, the modulus of elasticity is calculated by the formula given in the third chapter.

V. EXPERIMENTAL RESULTS.

For the complete discussion of the elastic nature of rocks, as many different elastic constants as the number of symmetry planes, which can be drawn in the rock, must be determined. As we have, however, no simple means of examining these symmetry planes, a single modulus of elasticity was determined relating to two mutually perpendicular directions, on the supposition that the material was isotropic.

The above enormously complicated method was applied to one hundred and fifty eight specimens of different kinds of several ages, and cost the author immense labor during one complete year. For all this labor and trouble expended to obtain but a poor result, he is consoled with Boyle's thought that, "men are oftentimes obliged to suffer as much wet and cold and dive as deep to fetch up sponges as to fetch up pearls."

The table at the end of the text contains the results arranged in the order of geological age; for the same geological age, those with the larger modulus come before those with the smaller. The velocity for longitudinal waves, calculated by the formula

$$V = \sqrt{\frac{E}{\rho}}$$

is also given in the table. The actual velocities of longitudinal waves in various rocks may differ from those given; the table, however, will probably furnish a rough estimate which may be of some use in seismometry.

Expressing the elastic constant of the rocks, classified according to the age of formation, by means of "the height from a fixed base line," Fig. I, we find a distinct gradation as we pass from the rocks of the Archæan age to those of the Cainozoic. Some of recent age may, of course, have a greater modulus of elasticity than those belonging to the older periods. As a whole, however, Archæan rocks come in first of all, while Cainozoic rocks come in last. The greatest and the least of the Archæan group are greater than those of the Palæozoic group respectively, and so on in turn for other periods. In the mean, the greater part of Archæan rocks have a greater modulus of elasticity than the greater part of Palæozoic rocks and so on.

The modulus of elasticity for a given rock may vary within wide limits as the density and other physical properties differ for each specimen. In the case of granite, e.g., No. 59₁ has the greatest value $E=5.93 \times 10^{11}$ while No. 71* the least value $E=1.25 \times 10^{11}$. c.g.s. unit. For engineers, it would be well to remember that in the case of any rock with unusually great density it does not necessarily follow that the modulus of elasticity is correspondingly great. For example, a piece of granite No. 63₁ has a density twelve percent greater than that of the other piece of granite No. 9₁, while the latter has its modulus of elasticity, on the contrary, forty-eight percent greater than the former. The possession of a greater modulus of elasticity and yet less density is what makes a material the more valuable.

As a general rule, however, rocks of recent formation have

a smaller modulus of elasticity and, at the same time, less density than those of older periods. The modulus of elasticity of old rocks increases very rapidly, more rapidly, indeed, than is proportional, as the density increases slowly.

The velocity of propagation for longitudinal waves as shown in the table, also increases with the age of formation of the rock in question. It may here be noted that, in so far as the present experiments go, the curve expressing the relation between the density and the velocity is somewhat concave towards the positive part of the axis along which the velocity is measured. That is to say, the increase of velocity is more rapid than the corresponding increase of density as the age of the formation becomes older.

VI. EFFECT OF MOISTURE.

In the present case, it being impossible to give specimens any desired amount of moisture, it is only intended to test whether the modulus of elasticity is or is not largely affected by the amount of moisture which might be present within the specimen.

To begin with, a specimen of sandstone was clamped in the usual way, and the wire was stretched with a known tension. When the specimen was in the ordinary dry state, it was found that the wire vibrated most violently when the half wave length was

$$l=10\cdot39 \text{ cm.}$$

Then the specimen was wrapped in a wet cloth in its clamped state and fed with a constant supply of water dropped upon it

for forty-two hours to moisten it throughout. It was then found that the corresponding half wave length had increased to about double, i.e.

$$l=20\cdot25 \text{ cm.}$$

which indicated that the modulus of elasticity had decreased to about one-fourth of its original value! Not without some doubt as to the result the author waited for one complete day till the specimen had apparently become dry, when it was found that it had nearly returned to its original state of elasticity; i.e.

$$l=10\cdot65 \text{ cm.}$$

On heating the specimen by hot air to drive out all the moisture, and then rapidly cooling it to the ordinary temperature, its elasticity increased slightly; i.e.

$$l=9\cdot89 \text{ cm.}$$

After three hours, it having returned to its ordinary state with regard to temperature and moisture, the elasticity became weakened to

$$l=10\cdot62 \text{ cm.}$$

The result of such cyclical observations shows clearly that the enormous diminution of the modulus of elasticity is actually caused by the effect of moisture. The difference between the initial $l=10\cdot39$ and the final $l=10\cdot62$ may be due to some variations of surrounding conditions,—probably a little relaxation of the clamp. As the first clamp is relaxed it results in an increase of the effective length of the specimen. The last difference corresponds to an increase of one mm. (or a little more) of the effective length.

The following result of the experiment may serve to give a rough notion as to the effect of moisture.

Rock.	Kind and age.	Density.		Elasticity $\times 11^{-10}$	
		Dry.	Wet.	Dry.	Wet.
Sandstone.	Sedimentary, Mesozoic.	2.230	2.351	10.15	3.17
Mica schist.	Metamorphic, Palæozoic.	2.647	2.669	17.54	9.21
Serpentine.	Eruptive, Archæan.	2.708	2.711	74.55	62.86

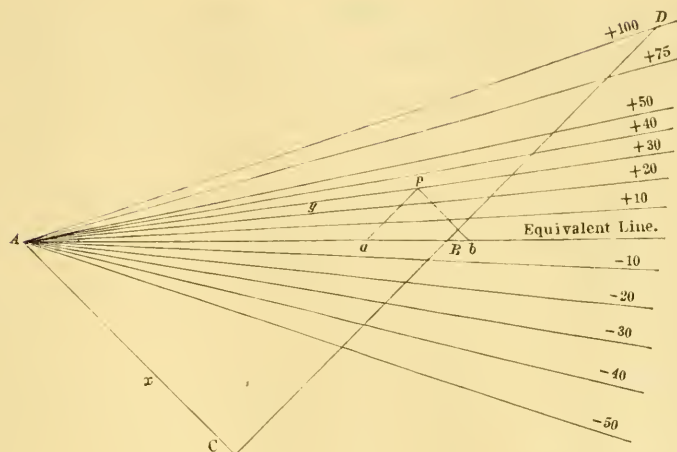
A glance at the above table will show what an important effect on the elastic nature of the earth crust is produced by the drops of water, which permeate beneath the earth's surface.

To study more closely the effect of moisture, and especially its effect as combined with high temperatures, a special arrangement is now in preparation, the author hopes to be able to give some observations on that special subject in the near future.

VII. RELATION BETWEEN THE KINETIC AND STATIC VALUES.

Of the one hundred and fifty eight specimens given in the table, a greater part have their elastic constants determined according to the statical method by either Professor H. NAGAOKA or by the author himself. Now it is of no small interest to compare the kinetic and the static values for one and the same specimen of rocks.

A short remark may here be added with respect to a new system of co-ordinates specially fitted for percentage representation.



Take a rightangled-isoscelestrianle ABC with its vertex C below the horizontal base AB . Divide each of the three sides into one hundred equal segments, and also in the produced part BD mark off any number of segments equal to one of the last. Join the vertex A with each of the points of section on the side BC and its produced part.

Let α and β be the corresponding values of any physical quantity in two different conditions \mathfrak{A} and \mathfrak{B} . From A measure a length Ax equal to α , the length of one segment being taken as the unit of measurement, on the side AC or its produced part. Then, from the end point x measure again a length xy equal to β in the direction parallel to the other side CB . If the last point y falls on the n^{th} of the previously drawn lines numbered from the base AB , then the physical quantity is said to have increased or decreased n percent while the condition varied from \mathfrak{A} to \mathfrak{B} , according as the line is above or below the base.

These premised, we have a new system of co-ordinates, in which the radius vector and the percentage are two independent

variables. It resembles a system of polar co-ordinates, but one variable 'percentage' is not proportional to an angle measured from any fixed line. If a point p (ρ_1, n_1) is given, then describe a rightangled-isosceles triangle apb , with the given point as the vertex and its base ab coinciding with AB . The two segments Aa and Ab represent the corresponding values in the two different conditions referred to, provided one of the last segments is taken as the unit of measurement.

In Fig. 2, the modulus of elasticity is represented in this co-ordinate system, its static and kinetic values corresponding to α and β respectively. It will be seen, at a glance, that when the radius vector is relatively small almost every point lies on the positive side, while a majority of those in which the radius vector is somewhat greater lie on the negative side. Generally speaking, so far as is shown by the present experiment, the percentage is enormously large for a small radius vector, but diminishes as the radius vector increases and ultimately it becomes even negative.

That the percentage diminishes as the radius vector increases is a matter of course, in so far as the phenomenon of yielding is the principal cause which makes the two values differ from each other. A negative value, however, can never be expected unless some other cause or causes exist beside the phenomenon of yielding.

Examining more closely, we see that the percentage rapidly diminishes and becomes even negative especially for those rocks which have a foliated structure as in the case of schists and slates. In schistose rocks, the percentage is generally negative as they have large moduli of elasticity and, at the same time, a distinctly foliated structure. Any eruptive rock, of whatever age it may be, has a positive percentage. Of sedimentary rocks, those in which

the moduli of elasticity are comparatively small have also a positive percentage, but some of them having large moduli may have negative percentages. The following table will show the facts more clearly.

Rock.	Total no. of specimens.	Mean value of the percentage.	Mean value of the modulus of elasticity.
Sandstone.	6	+38	1.57×10^{11}
Tuff.	7	+23	1.92
Andesite.	13	+20	2.12
Granite.	5	+11	3.14
Slate.	17	- 6	4.69
Peridotite-serpentine.	6	+ 4	6.29
Schists.	10	-10	6.39

Here it must be noted that I do not mean to say that the percentage would be always negative for any old rock having a distinctly foliated structure. That the percentage diminishes as the radius vector increases would in all probability be true; its becoming negative, however, may be due to some other causes. The two series of experiments have been made under very different surrounding conditions. The effect of moisture, for instance, is never negligible as some observations were made during the wet summer season; while the others, during the dry cold of winter.

Any complete discussion of the relation between the static and the kinetic values must be postponed, at least, until the effects of temperature and moisture on the elastic constants have been clearly investigated. The numerical values hitherto given for the moduli of elasticity of several rocks must be taken only as rough estimates.

The only closing remark that can be properly added is that the result of these experiments as a whole has only brought the author, who at first sight thought he had found a quarry of research that would soon be exhausted, to the threshold of a labyrinth, where many paths invites him to proceed further.

In conclusion, I wish to express my great indebtedness to Dr. N. FUKUCHI of the Geological Laboratory, for valuable information concerning the geological characters of the specimens. My best thanks are due to Professor H. NAGAOKA, under whose kind guidance I have carried out the experiments.

June 1905.

Physical Laboratory, College of Science,
Tōkyō Imperial University.

Modulus of Elasticity for 158 Specimens of Rocks.

Specimen No.	Rock.	Locality.	Kind.	Density.	Modulus of Elasticity.			Velocity of longitudinal wave.
					E_1	E_2	E	
ARCHÆAN ROCKS.					c.g.s. $\times 10^{11}$			Km. Sec.
50.*	Chlorite schist.	Chichibu.	Metamorphic.	2.96	9.79	12.39	11.09	6.12
9.*	"	"	"	2.98	10.69	10.88	10.78	6.02
72.	Peridotite } (Serpentinized). }	Kuji, Ibaraki.	Eruptive } (Altered). }	2.61	7.72	9.74	8.73	5.78
81.	Serpentine.	Chichibu.	"	2.72	9.05	6.98	8.02	5.43
46j.	Quartz schist.	Kashiwagi, Gumma.	Metamorphic.	2.64	5.99	8.91	7.45	5.31
31j.	Quartz schist.	Onishi, Gumma.	Metamorphic.	2.67	7.66	7.19	7.43	5.28
18j.	Chlorite schist.	Nogami, Chichibu.	"	2.88	6.59	7.19	6.89	4.89
16.*	Peridotite } serpentine. }	Ibaraki.	Eruptive.	2.83	6.55	7.07	6.81	4.91
22j.	Gabbro.	Nogami, Chichibu.	"	2.71	5.95	7.26	6.61	4.94
262.	Chlorite schist.	Kunikami, } Chichibu. }	Metamorphic.	2.87	5.21	6.35	5.78	4.49
91j.	Chlorite schist.	Chichibu.	Metamorphic.	2.88	5.78	5.37	5.58	4.41
45j.	"	Nogami, Chichibu.	"	2.77	5.46	5.54	5.50	4.46
26j.	"	Kunikami, } Chichibu. }	"	2.82	5.55	5.35†	5.45	4.39
28.	Graphite schist.	Onishi, Gumma.	"	2.59	5.39	5.07	5.23	4.50
41a.*	Peridotite } serpentine. }	Kuji, Ibaraki.	Eruptive.	2.78	5.13	4.96	5.04	4.27
24j.	Graphite schist.	Kunikami, } Chichibu. }	Metamorphic.	2.59	4.88	5.15	5.02	4.41
49j.	Chlorite schist.	Nogami, Chichibu.	"	2.77	4.84	5.00	4.92	4.22
41b.*	Peridotite } serpentine. }	Kuji, Ibaraki.	Eruptive.	2.79	4.52	4.86	4.69	4.10
60j.	Gneiss.	Shinshiro, Mikawa.	Metamorphic.	2.59	4.02	4.98	4.50	4.17
17.*	Peridotite } serpentine. }	Kuji, Ibaraki.	Eruptive.	2.57	4.21	4.67	4.44	4.16
47j.	Quartz schist.	Onishi, Gumma.	Metamorphic.	2.63	4.82	3.34	4.08	3.94
23j.	Graphite schist.	Kunikami, } Chichibu. }	"	2.56	4.05	4.02	4.04	3.98
30.	Chlorite schist } (Decomposed). }	Onishi, Gumma.	"	2.64	3.96	4.11	4.03	3.91
PLÆOZOIC ROCKS.								
67j.	Schalsteine.	Asakuma-dake, Ise.	Sedimentary.	2.98	9.35	9.90	9.62	5.68
122.	Clay slate.	Miyanomaye, Anmi.	"	2.71	9.26	8.84	9.05	5.78
69j.	Pyroxenite.	Isosuzu-gawa, Ise.	Metamorphic.	3.05	8.85	8.87	8.86	5.40
78b.*	Schalsteine.	China.	Sedimentary.	2.77	8.01	8.60	8.30	5.48
78a.*	"	"	"	2.77	8.34	7.87	8.11	5.41

(Continued.)

Specimen No.	Rock.	Locality.	Kind.	Density.	Modulus of Elasticity.			Velocity of longit. wave.
					E_1	E_2	E	
65 ₁ .	Schalsteine.	Kamuro, Kii.	Sedimentary.	2.84	8.32	7.80	8.06	5.33
71 ₁ .	Limestone.	Akasaka, Gifu.	"	2.71	7.82	7.54	7.68	5.33
32 ₁ .	Pyroxenite.	Hominoyama, } Gumma. }	"	2.90	7.81	7.52	7.67	5.15
2 _b .*	Clayslate.	?	"	2.69	7.61	7.47	7.54	5.30
34 ₁ .	Adinolslate.	Yonowo, Gumma.	"	2.64	7.54	7.45	7.50	5.33
13.*	Limestone.	Kanagawa.	Sedimentary.	2.65	7.43	7.52	7.48	5.31
2 _a .*	Clayslate.	?	"	2.67	7.77	7.13	7.45	5.28
29.*	Limestone.	Mikawa.	"	2.68	6.68	7.11	6.89	5.07
79.*	Schalsteine.	Rikuchū.	"	2.65	6.75	6.70	6.72	5.04
74 ₁ .	Limestone.	Akasaka, Gifu.	"	2.69	6.66	6.65	6.65	4.97
55.*	Limestone.	Musashi.	Sedimentary.	2.63	6.55	6.62	6.58	5.01
71 ₂ .	"	Akasaka, Gifu.	"	2.69	6.67	6.30	6.48	4.91
11 _b .*	Marble.	Ibaraki.	"	2.63	6.26	6.14†	6.20	4.86
73.*	Sandyslate.	Rikuchū.	"	2.64	6.13	6.05	6.09	4.81
80.*	Schalsteine.	"	"	2.82	5.77	6.23	6.00	4.62
72 ₁ .	Limestone.	Akasaka, Gifu.	Sedimentary.	2.69	5.87	6.13	6.00	4.72
59 ₁ .	Granite.	Okazaki, Mikawa.	Eruptive.	2.63	5.92	5.94	5.93	4.75
74.*	Clayslate.	Nikkō.	Sedimentary.	2.15	5.69	5.72	5.70	5.15
1 _a .*	Weathered } clayslate. }	Umebatake.	"	2.31	5.13	5.93	5.53	4.89
87 ₁ .	Ophicalcite.	Arakawa, Chichibu.	Eruptive.	2.65	4.91	5.30	5.11	4.39
21 ₁ .	Limestone.	Nogami, Chichibu.	Sedimentary.	2.64	5.31	4.76	5.04	4.37
1 _b .*	Weathered } clayslate. }	Umebatake.	"	2.30	4.97	4.58	4.77	4.55
9 ₁ .	Granite.	Mikage, Settsu.	Eruptive.	2.54	4.88	4.61	4.75	4.32
76 ₁ .	Slate.	Atago, Yamashiro.	Sedimentary.	2.24	4.61	4.83	4.72	4.59
40 ₁ .	Micaschist.	Fudō-tōge, Ibaraki.	Matemorphic.	2.54	4.25	4.81	4.53	4.22
69*.	Granite.	Kagawa.	Eruptive.	2.57	4.53	4.42	4.47	4.17
81 ₁ .	"	Tamba.	"	2.62	4.46	4.46	4.46	4.13
64 ₁ .	"	Nishiura, Mikawa.	"	2.61	4.53	4.30	4.42	4.11
66 ₂ .	"	Shirakawa, Kyōto.	"	2.62	4.28	4.01	4.14	3.98
79 ₁ .	Slate.	Narutaki, Kyōto.	Sedimentary.	2.45	3.90	4.26	4.08	4.09
75 ₁ .	Limestone.	Akasaka, Gifu.	Sedimentary.	2.72	3.55	4.59†	4.07	3.87
66 ₁ .	Granite.	Shirakawa, Kyōto.	Eruptive.	2.62	4.03	—	—	3.93
63.	Marble.	Maiyama, Ibaraki.	Sedimentary } (Metamorphosed.) }	2.68	3.48	3.89	3.69	3.71
3 _b .*	Clayslate.	Tamba.	"	2.39	3.63	—	—	3.90
60 _b .*	Weathered } clayslate. }	Yamashiro.	"	2.31	3.65	3.49	3.57	3.94

(Continued.)

Specimen No.	Rock.	Locality.	Kind.	Density.	Modulus of Elasticity.			Velocity of longit. wave.
					E_1	E_2	E	
44 ₁ .	Granite.	Hyōgo, Settsu.	Eruptive.	2.59	3.49	3.33	3.41	3.63
63 ₂ .	"	Nishiura, Mikawa.	"	2.84	3.35	3.37	3.36	3.44
12 _a .*	Marble.	Ibaraki.	Sedimentary.	2.65	3.35†	—	—	3.56
10 ₂ .	Granite.	Kitaki, Kagawa.	Eruptive.	2.57	3.24	—	—	3.55
63 ₁ .	"	Nishiura, Mikawa.	"	2.84	3.40	3.02†	3.21	3.36
60 _a .*	Weathered } clayslate. }	Yamashiro.	Sedimentary.	2.32	3.66	2.72†	3.19	3.72
3 _a .*	Clayslate.	Tamba.	"	2.37	3.17	—	—	3.65
78 ₂ .	Slate.	Narutaki, Kyōto.	"	2.42	3.13	3.16	3.14	3.59
12 _b .*	Marble.	Ibaraki.	"	2.65	3.68†	2.60†	3.14	3.44
78 ₁ .	Slate.	Narutaki, Kyōto.	"	2.44	3.08	—	—	3.55
80 ₁ .	Slate.	Atago, Kyōto.	Sedimentary.	2.36	2.99	3.00	3.00	3.56
27 ₁ .	Micaschist.	Motoizumi, } Chichibu. }	Metamorphic.	2.63	2.71	3.15	2.93	3.35
29 ₁ .	Limestone.	Onishi, Gumma.	"	2.66	2.40	2.85	2.63	3.15
64 _a .*	Clayslate.	Tochigi.	Sedimentary.	2.46	2.63	2.46	2.54	3.21
82 ₁ .	Contact slate.	Tamba.	"	2.33	2.75	2.23	2.49	3.27
68.*	Granite.	Kitaki, Kagawa.	Eruptive.	2.55	2.19	1.67†	1.98	2.79
52.*	"	Ibaraki.	"	2.50	1.80†	—	—	2.68
7 _a .*	Weathered } clayslate. }	"	Sedimentary.	2.50	1.53	1.58	1.56	2.50
65 _a .*	"	"	"	2.49	1.54	1.53	1.53	2.48
7 _b .*	"	"	"	2.50	1.51	1.44	1.47	2.43
65 _b .*	Weathered } clayslate. }	Ibaraki.	Sedimentary.	2.50	1.38	1.37	1.37	2.34
56.*	Granite.	"	Eruptive.	2.53	1.36	1.20	1.28	2.25
71.*	"	"	"	2.59	1.28	1.23	1.25	2.20
42 ₁ .	Mica schist.	Tsukioka, Ibaraki.	Metamorphic.	2.64	1.08	1.29	1.19	2.12
61.	Pegmatite.	Hōjō, Ibaraki.	Eruptive.	2.57	1.16	1.10	1.13	2.10

MESOZOIC ROCKS.

53.*	Clayslate.	Rikuzen.	Sedimentary.	2.70	7.80	7.39	7.59	5.30
77.*	Schalsteine.	Akamagaseki.	"	2.78	6.46	6.52	6.49	4.85
72.*	Clayslate.	Rikuzen.	"	2.71	6.54	6.38	6.46	4.89
76.*	"	?	"	2.71	6.42	6.38	6.40	4.86
62 _a .*	"	Tsushima.	"	2.68	4.39	4.25	4.32	4.02
68 ₁ .	Granite.	Yoshima, Kagawa.	Eruptive.	2.61	3.42	3.40	3.41	3.62
5.*	Sandstone.	Kii.	Sedimentary.	2.22	1.32	1.50	1.41	2.52
85 ₁ .	"	Kyūshū.	"	2.34	1.29	1.30	1.30	2.36
6 _b .*	"	Kii.	"	2.22	1.23	1.00	1.11	2.23
83 ₁ .	"	Kyūshū.	"	2.09	1.03	1.07	1.05	2.24

(Continued.)

Specimen No.	Rock.	Locality.	Kind.	Density.	Modulus of Elasticity.			Velocity of longit. wave.
					E_1	E_2	E	
841.	Sandstone.	Kyūshū.	Sedimentary.	2.24	1.02	1.05	1.03	2.15
6a.*	"	Kii.	"	2.24	1.02	0.95†	0.98	2.09
CAINOZOIC ROCKS.								
511.	Andesite.	Shinano.	Eruptive.	2.61	4.37	4.35	4.36	4.09
172.	"	Haruna, Gumma.	"	2.63	4.17	3.94	4.06	3.94
1.	"	Nebukawa, Sagami.	"	2.59	3.96	—	—	3.91
54.*	"	"	"	2.56	4.12	3.53	3.83	3.87
351.	Sandstone.	Mitagawa, } Chichibu. }	Sedimentary.	2.47	3.65	3.41	3.53	3.78
12.	Andesite.	Nebukawa, Sagami.	Eruptive.	2.59	3.45	3.59	3.52	3.69
15*.	"	Komatsu, Sagami.	"	2.20	3.32	3.10	3.21	3.82
521.	Rhyolite.	Hōraiiji, Mikawa.	"	2.20	3.20	3.08	3.14	3.80
571.	Porphyllite.	Arumi, Mikawa.	"	2.29	3.31	2.94	3.12	3.70
51.*	Rhyolite.	Honbun, Izu.	"	2.32	3.12	3.10	3.11	3.66
50.	Andesite.	Nakatsugaru, } Mutsu. }	Eruptive.	2.69	2.79	2.90	2.85	3.26
14.*	Tuff.	Nanasawa, Sagami.	Sedimentary.	2.22	2.91	2.66	2.79	3.55
28.*	Andesite.	Izu.	Eruptive.	2.17	2.49	2.87	2.68	3.52
30.*	Tuff.	Kiga, Izu.	Sedimentary.	2.17	2.51	2.64	2.57	3.45
8a.*	Rhyolite tuff.	Iyo.	"	2.35	2.48	2.36	2.42	3.21
39.*	Andesite.	Yokone, Izu.	Eruptive.	2.40	2.39	2.35	2.37	3.14
10.*	Tuff.	Yoshida, Izu.	Sedimentary.	2.28	2.29	2.39	2.34	3.21
70.*	Andesite.	Komatsu, Sagami.	Eruptive.	2.46	2.40	2.23	2.31	3.07
581.	Sandstone.	Yebi, Mikawa.	Sedimentary.	2.21	2.33	2.27	2.30	3.23
8b.*	Rhyolite tuff.	Iyo.	"	2.32	2.22	2.38	2.30	3.15
19b.*	Tufaceous } sandstone. }	Tomioka, Gumma.	Sedimentary.	2.32	2.15	2.31	2.23	3.10
561.	"	Yebi, Mikawa.	"	2.12	2.17	2.12	2.15	3.19
63a.*	Rhyolite tuff.	Nakura, Mikawa.	"	2.15	2.15	2.11	2.13	3.14
19a.*	Tufaceous } sandstone. }	Tomioka, Gumma.	"	2.31	2.08	2.01	2.04	2.97
59b.*	Rhyolite.	Gumma.	Eruptive.	2.45	1.94	1.93†	1.94	3.82
531.	Rhyolite tuff } (Weathered). }	Hōraiiji, Mikawa.	Sedimentary.	2.16	1.78	1.87	1.83	2.91
4a.*	Tuff.	Sawada, Izu.	"	1.84	1.78	1.84†	1.81	3.14
59a.*	Rhyolite.	Gumma.	Eruptive.	2.47	1.88	1.64	1.76	2.67
67a.*	Andesite tuff.	Midera, Yechizen.	Sedimentary.	2.44	1.74	1.73	1.73	2.66
57.*	Tuff.	Nawazi, Izu.	"	2.04	1.67	1.70†	1.69	2.88

(Continued.)

Specimen No.	Rock.	Locality.	Kind.	Density.	Modulus of Elasticity.			Velocity of longit. wave.
					E_1	E_2	E	
67 _b .*	Andesite tuff.	Midera, Yechizen.	Sedimentary.	2.40	1.63	1.72	1.68	2.65
54 _i .	Tufaceous sandstone.	Nebukawa, Sagami.	"	2.07	1.55	1.63	1.59	2.77
46 _b .*	Andesite.	Manazuru, Sagami.	Eruptive.	2.55	1.56	1.55	1.55	2.47
21.	Tuff.	Kawatsu, Izu.	Sedimentary.	1.91	—	1.50	—	2.80
40.*	Andesite.	Sagami.	Eruptive.	2.30	1.54	1.45	1.49	2.54
61 _b .*	Rhyolite tuff.	Iwashiro.	Sedimentary.	2.20	1.46	1.48	1.47	2.59
36.*	Tuff.	Izu.	"	1.85	1.65	1.27	1.46	2.81
49 _b .*	Andesite.	"	Eruptive.	2.21	1.46	1.39	1.42	2.54
4 _b .*	Tuff.	Kawatsu, Izu.	Sedimentary.	1.82	1.45	1.39	1.42	2.79
55 _i .	Tufaceous sandstone.	Hōrai-ji, Mikawa.	"	2.09	1.44	1.35	1.39	2.58
47.*	Andesite.	Yenoura, Shiruga.	Eruptive.	2.43	1.36	1.35	1.35	2.36
61 _a .*	Rhyolite tuff.	Iwashiro.	Sedimentary.	2.23	1.37	1.30	1.34	2.45
22.*	Tuff.	Teishi, Izu.	"	2.01	1.30	1.35	1.32	2.56
58.*	Sandstone.	Chōshi, Chiba.	"	2.35	1.35	1.26	1.30	2.35
53.	Rhyolite.	Midera, Yechizen.	Eruptive.	2.40	1.09	1.28	1.18	2.22
16.	Andesite.	Haruna, Gumma.	Eruptive.	2.32	1.21	1.14	1.18	2.26
32.*	Rhyolite tuff.	Mitaka, Izu.	Sedimentary.	1.89	1.21	1.02	1.11	2.42
37.*	Quartz sandstone.	Hizen.	"	2.23	1.02	1.21	1.11	2.23
38.*	Andesite.	Izu.	Eruptive.	1.94	1.05	1.17	1.11	2.39
43.	Sandstone.	Shinjō, Kii.	Sedimentary.	2.25	1.04	1.13	1.08	2.19
23.*	Andesite tuff.	Yema, Izu.	Sedimentary.	1.83	1.00	0.98	0.99	2.33
34.*	Andesite.	Manazuru, Sagami.	Eruptive.	2.02	0.96	0.95	0.95	2.17
66.*	Rhyolite tuff.	Amakusa, Hizen.	Sedimentary.	2.26	0.96†	0.62†	0.79	1.87
31.*	Tuff.	Teishi, Izu.	"	1.92	0.78	0.77	0.78	2.02
48.*	Andesite	Izu.	Eruptive.	2.10	0.63	—	—	1.73
32.	Sandstone.	Chōshi, Chiba.	Sedimentary.	2.20	0.56	0.62	0.59	1.63
21.*	Andesite tuff.	Izu.	"	1.50	0.42	0.50	0.46	1.76
35.*	Tuff.	"	"	1.29	0.26†	—	—	1.43

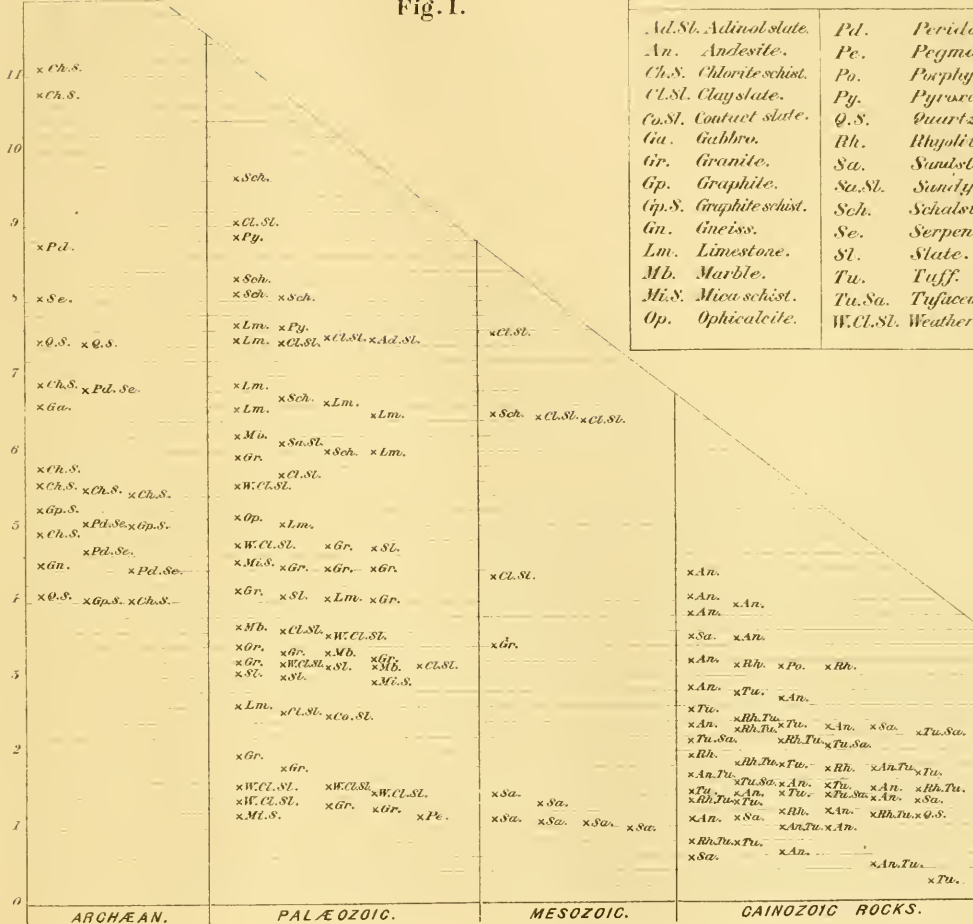
N.B. The specimens marked with * are those whose elastic constants were statically determined by Professor H. NAGAOKA and published in "The Pub. of the E.I.C. in F.L." No. 4. 1900. and Phil. Mag. 1900.

The specimens marked with † are those which were found to have been crushed or broken at the clamped section so that the value given in the table may be erroneous.

MODULUS OF ELASTICITY.

$$E = 12 \times 10^{10} \text{ c. g. s.}$$

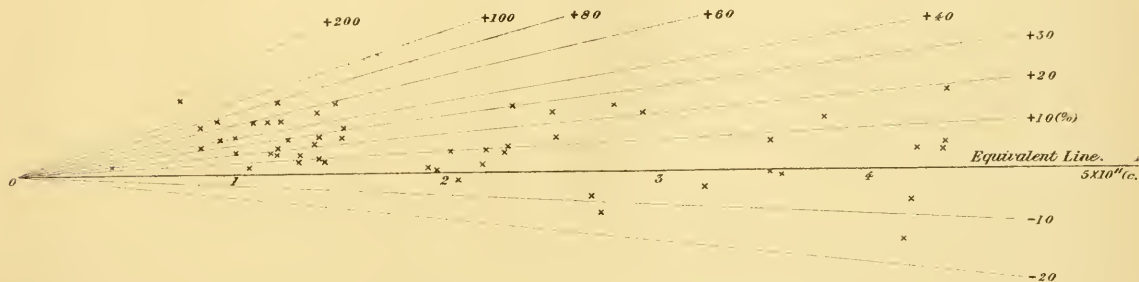
Fig. 1.



ABBREVIATIONS.

<i>Ad. Sl.</i> Adinot slate.	<i>Pd.</i> Peridotite.
<i>An.</i> Andesite.	<i>Pe.</i> Pegmatite.
<i>Ch. S.</i> Chlorite schist.	<i>Po.</i> Porphyrite.
<i>Cl. Sl.</i> Clay slate.	<i>Py.</i> Pyroxenite.
<i>Co. Sl.</i> Contact slate.	<i>Q. S.</i> Quartz schist.
<i>Ga.</i> Gabbro.	<i>Rh.</i> Rhyolite.
<i>Gr.</i> Granite.	<i>Sa.</i> Sandstone.
<i>Gp.</i> Graphite.	<i>Sa. Sl.</i> Sandy slate.
<i>Gp. S.</i> Graphite schist.	<i>Sch.</i> Schist.
<i>Gn.</i> Gneiss.	<i>Se.</i> Serpentine.
<i>Lm.</i> Limestone.	<i>Sl.</i> Slate.
<i>Mb.</i> Marble.	<i>Tu.</i> Tuff.
<i>Mi. S.</i> Mica schist.	<i>Tu. Sa.</i> Typhaceous sandstone.
<i>Op.</i> Opicalcite.	<i>W. Cl. Sl.</i> Weathered Cl. Sl.

Fig. 2.



On Two New Species of *Chimæra*.

By

Shigeho Tanaka, *Rigakushi*.

With two plates and one woodcut.

There are eight species of *Chimæra* known to be extant,
viz :—

- C. monstrosa* LINNÆUS. GÜNTHER, Catalogue of fishes, Vol. VIII., 1870, pp. 349–350.
- C. affinis* CAPELLO. GÜNTHER, Catalogue of fishes, Vol. VIII., 1870, pp. 350–351.
- C. collieri* LAY and BENNET. GÜNTHER, Catalogue of fishes, Vol. VIII., 1870, p. 350.
- C. ogilbyi* WAITE. Mem. Australian Mus., IV., Pt. I., 1899, p. 48, Pl. VI.
- C. neglecta* OGILBY. WERNER, Zool. Jahrbücher, Bd. 21, 1905, p. 276.
- C. phantasma* JORDAN & SNYDER. Proc. Nat. Mus., Vol. XXIII., 1903, pp. 338–339.
- C. mitsukurii* DEAN. Journal College Science, Vol. XIX., Art. 3, 1904, pp. 6–9, Pl. I., figs. 1–2.
- C. purpurascens* GILBERT MS. JORDAN & SNYDER, Smithsonian Miscellaneous Collections, Vol. 45, 1904, p. 235.

Last winter, from the last part of January to the middle of February, there were brought into Mr. OWSTON's office in Yokohama twenty-three specimens of *Chimæra*, all taken in the Sagami Sea, off the village of Inatori, Idzu. He generously turned them over to me for examination. There also came about the same time to the Zoölogical Institute of the Science College two specimens from the Tokyo market, said to have come from the same locality off Idzu. A careful examination of all these specimens has convinced me that they do not belong to any of the hitherto known eight species and that they must be referred to two new species, for which the specific names *jordani* and *owstoni* are proposed.

It is necessary for me to add here that I am under very deep obligations to Prof. Dr. MITSUKURI for superintending my study and for his careful corrections of the manuscripts in the preparation of this article. I wish also to thank Mr. OWSTON for his generosity in placing his specimens at my disposal for examination.

CHIMÆRA JORDANI N. SP. Pl. I., fig. 1.

The points of the species which strike us at a glance are (1) that the lateral canal of the sensory canal system runs straight on the side of the body almost without any sinuation, (2) that a deep notch lies between the anal fin and the lower lobe of the caudal, and (3) that the head and body are of a uniformly brown color.

The following is a detailed description of the species.

Head measured from tip of snout to first gill-opening contained $4\frac{5}{8}$ times, and greatest height of body in front of the posterior

end of the insertion of first dorsal $5\frac{2}{3}$ times, in the total length of body (excluding the parts from the end of the second dorsal to the end of caudal filament); snout about 2, eye $3\frac{1}{2}$, interorbital $4\frac{1}{2}$ –5 in head; height of head in front of the insertion of pectoral a little lower than the greatest height of body; the height in front of eye $1\frac{1}{2}$ – $1\frac{3}{4}$ in the height of body; spine of the first dorsal curved backwards, a little longer than the length of head and higher than the first ray of the first dorsal, triangular in cross section, smooth with a median keel anteriorly, grooved posteriorly, the distal third of its length with recurved spinules; this spinous roughness is weaker than in *phantasma* and stronger than in *mitsukurii*; first dorsal subcontinuous with second dorsal by a fold of rayless skin; height of the anteriormost ray of first dorsal exclusive of its fleshy base $1\frac{1}{2}$ in head; free margin of the first dorsal almost straight; external margin of the second dorsal even and slightly concave, its posterior margin rounded; height of the fin, measured perpendicular to the upper margin of body at a point two-sevenths of its length from the anterior end, $4\frac{2}{3}$ in head. Upper lobe of caudal slightly higher than the lower; height of the former measured perpendicular to the upper margin of body 7 in head; second dorsal and upper lobe of caudal continuous with a deep notch. Anal very low, falcate, continuous with the lower lobe of caudal, but separated by a deep notch opposite the dorsal notch and similar to but deeper than that of *phantasma*. Both caudal lobes nearly as high as in *mitsukurii*; as in that species as well as in *phantasma* the lower lobe extends more posteriorly than the upper lobe. Distance from the dorsal notch to the end of caudal filament 2 in body exclusive of head and the parts behind dorsal notch; in this proportion the species agrees with *phantasma*, but not with *mitsukurii* in which the distance from the dorsal

notch to the end of caudal filament is equal to the length of body.

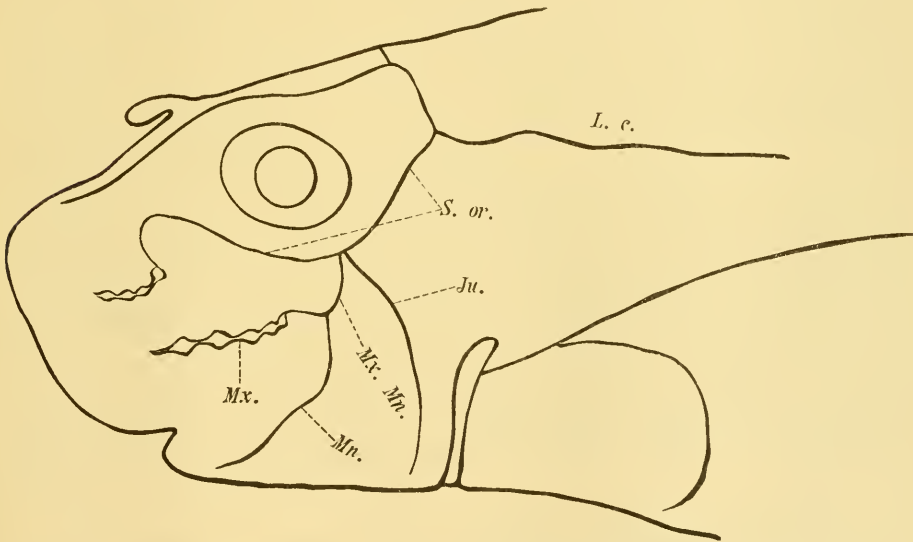
Pectoral pointed and slightly falcate, with a deep notch at its lower insertion in the fleshy base; its tip reaches far behind the insertion of ventral when depressed. Insertion of the ventral midway between tip of head and notch of second dorsal, its tip subtruncate, its inner margin rounded. Distance between origin of second dorsal and insertion of pectoral a little shorter than the distance between the latter and the insertion of ventral.

There exists no difference in external features between the male and the female except in the sexual characters. Cephalic organ in the male directed forwards and downwards, situated on the snout in front of the anterior margin of the eye; its length 2 in eye; on its lower side about sixty or more recurved spinous denticles, very much like those of *phantasma* or *mitsukurii*. Clasper tripartite; its tip covered with fine shagreen as usual; its length from the insertion $1\frac{2}{3}$ in head; its division at a point two-thirds of its length, as in *purpurascens* and *owstoni* (Pl. I., fig. 3), but unlike *phantasma* in which the point of division is at one-third of the length (Pl. I., fig. 4), while in *mitsukurii* the clasper is rather short, bipartite, and the point of division situated halfway of its length. In a young specimen, which measures 42.5 centimetres in total length exclusive of the parts behind the dorsal notch and in which the cephalic organ is still embedded in the skin, the claspers measure 1.6 centimetres in total length and 1 centimetre in the length from the insertion to the point of division; they are already tripartite. In a young *phantasma* 35 centimetres long and with the cephalic organ still embedded in the skin, the claspers are still bipartite. In all the Japanese species I have found the anterior ventral

clasping organ armed with five spinous denticles on the inner side.

Teeth confluent; five or six rods in each anterior lamina of the upper jaw; the margin of the lamina sinuate and slightly convex; lateral rods behind the anterior lamina low, oblique, their tips directed towards the median part. Mandibular laminæ included within the upper laminæ; rods in the laminæ rather indistinct, margin of lamina with two concavities and more or less indistinctly sinuate. Peritoneum lining the body cavity unpigmented; wall of digestive canal of a dusky color.

Lateral canal of the sensory canal system straight almost



Lateral view of the head of a *Chimæra*, explaining nomenclature of the sensory canal system adopted. (After Mr. COLLINGE'S nomenclature.) *Ju.*, Jugular branch; *L. C.*, Lateral canal; *Mx. Mn.*, Maxillo-mandibular branch; *Mx.*, Maxillary division of the maxillo-mandibular; *Mn.* Mandibular division of the maxillo-mandibular; *S. or.*, Suborbital branch.

without any sinuation. It shows an interesting feature in the suborbital part. From the suborbital branch of the canal system

below the posterior margin of the eye, there branch off a maxillo-mandibular and a jugular branch sometimes at the same point (Pl. II., fig. 15), at other times the latter from the former (Pl. II., fig. 12), and at still other times the two separately from the suborbital (Pl. II., figs. 13 and 14). This variation may go so far that in one and the same individual the two branches, the jugular and the maxillo-mandibular, may arise at the same point on one side, while on the other side, the origin of the jugular may be shifted a greater or less distance along either the suborbital or the maxillo-mandibular branch as mentioned above. In *phantasma* and *mitsukurii* such variations seem never to occur. The origin of the jugular seems to be constant for each of the species. In *phantasma* it arises always from the suborbital (Pl. II., fig. 6), while in *mitsukurii* it is given off invariably from the maxillo-mandibular (Pl. II., fig. 16). So far as I was able to examine specimens of *jordani*, I came to the conclusion that in this species the points of origin of the maxillo-mandibular and of the jugular, whether the latter arises from the former or directly from the suborbital, are considerably nearer each other than in *phantasma* or in *mitsukurii* (cf. Pl. II., figs. 6, 12, 13, 14, and 16). Individual differences with respect to this part of the sensory canal system I have observed in *purpurascens* also (Pl. II., figs. I and 5).

Color in formalin uniformly dark brown; as Mr. OWSTON tells me, a female when brought in by a fish-monger was beautifully iridescent; one indistinct pale line above the lateral canal and three indistinct pale lines below it run parallel to one another in the posterior part of the body; posterior margin of the pectoral and ventral fins blackish; free margins of all other three fins with a more or less broad blackish band; color of second

dorsal fading out abruptly towards its base; numerous transverse series of dark dots above the lateral canal on the side of body as shown in the figure of the next species.

This species and the next are intermediate in many respects between *phantasma* and *mitsukurii*. According to our collector, KUMA, *phantasma* is taken with long line at a depth of two hundred and fifty to three hundred hiro¹⁾ in the fishing grounds near Misaki, Province of Sagami, and *mitsukurii* at a depth of three hundred to four hundred and fifty hiro in the same grounds. The ground off Inatori where *jordani* and *owstoni* have been taken is some five hundred or more hiro deep. From the ground of capture as well as from their dusky coloration and large eyes, the two species seem to be residents of deeper regions than either *phantasma* or *mitsukurii*. The male specimen here figured and a female are deposited as types in the museum of the Zoölogical Institute, Tokyo Imperial University.

To sum up, the species is characterized by the following points:—uniformly dark coloration; large eye; first dorsal spine showing rather distinct roughness, the same spine projecting out beyond the end of the anteriormost ray of first dorsal; large pointed pectoral; distinct anal; caudal filament as long as that of *phantasma*; height of caudal much greater than in *phantasma*; almost straight lateral canal.

The species is named after Dr. DAVID STARR JORDAN, of the Leland Stanford Junior University, in recognition of his extensive work on fishes of Japan.

The measurements of the species are as follows:

1) One hiro is a little less than five feet.

MEASUREMENTS

	MALE.			
Total length (exclusive of parts behind dorsal notch)	62.0	60.0	55.5	42.5
Length from dorsal notch to end of filament.....	28.0	23.5	23.5	25.0
Length of head (to first gill opening)	? 10.7	10.6	? 9.5	9.2
Height of head behind eye	8.9	9.0	8.8	6.5
Height of head in front of eye	8.15	7.5	7.15	5.5
Greatest height of body (in front of the posterior end of the insertion of first dorsal)	10.7	9.2	10.5	7.5
Long. diameter of eye.....	3.6	3.3	3.7	2.8
Diameter of pupil	1.65	1.7	1.6	1.2
Long. diameter of iris	3.1	3.0	2.9	2.2
Length of snout	4.1	5.7	4.4	4.4
Interorbital width	3.1	2.7	2.8	2.1
Length of dorsal spine	? 11.6	12.1	13.0	8.7
Height of anteriormost ray of first dorsal (exclusive of its fleshy base)	11.4	10.5	10.1	6.6
Height of highest part of second dorsal (measured perpendicular to upper margin of body)	2.3	2.3	2.2	2.0
Height of lowest part of second dorsal	1.5	1.85	1.55	1.7
Upper margin of pectoral (excl. of its fleshy base).	19.0	16.0	17.2	11.3
Breadth of pectoral at insertion of base	5.0	5.0	4.0	3.0
External margin of ventral (exclusive of its fleshy base)	9.0	8.1	7.6	5.8
Breadth of ventral at insertion of base	2.6	2.2	2.0	1.5
Height of upper lobe of caudal	1.25	1.1	1.2	1.1
Height of lower lobe of caudal	1.25	1.0	1.2	1.05
Length of cephalic organ.....	2.05	1.7	1.7	?
Length of clasper from its insertion	7.0	6.0	6.0	1.6
Length of clasper from insertion to the point of division	4.65	4.1	3.9	1.0
Distance between insertion of pectoral and that of ventral	20.0	18.0	18.5	12.0
Distance between insertion of the dorsal spine and that of pectoral.....	9.1	9.0	8.4	5.8
Distance between base of ventral and anal notch.	30.0	31.5	26.5	21.0

All the measurements are

OF THE SPECIES.

FEMALE.											
63.5	60.0	58.5	57.1	63.0	39.0	50.5	56.5	69.0	62.5	51.0	64.0
23.0	27.0	25.5	23.0	?26.0	22.5	23.5	28.5	?20.0	?	29.0	25.0
12.8	12.4	?11.9	12.0	12.6	8.1	10.4	11.8	?12.0	?12.9	11.1	?11.5
9.3	8.85	9.0	9.9	10.3	6.0	7.7	9.0	8.8	10.35	8.3	9.3
8.4	8.35	7.7	7.85	8.4	5.35	6.6	7.5	8.3	9.15	7.25	8.45
11.3	10.8	9.9	11.4	11.3	6.6	9.1	11.0	11.0	10.7	8.5	11.2
3.7	3.6	3.3	3.5	3.8	2.6	3.0	3.5	3.8	4.0	3.2	4.1
1.5	1.6	1.6	1.65	1.7	1.4	1.7	1.75	1.65	1.8	1.5	1.9
2.7	2.9	2.8	2.7	3.0	1.9	2.8	3.0	2.95	3.5	2.5	3.1
6.2	5.8	5.0	6.3	5.6	4.1	5.0	4.9	5.2	5.3	6.0	5.2
2.3	2.8	2.8	2.7	2.3	1.5	2.6	2.6	2.8	2.9	2.2	2.6
12.9	?10.8	12.5	12.7	? 9.3	6.6	10.1	? 9.8	12.2	12.0	9.4	12.6
9.9	10.5	10.5	10.9	10.0	5.5	7.7	9.6	10.0	9.4	7.1	10.5
2.7	2.5	2.0	2.6	2.7	1.8	2.5	2.8	2.6	2.2	2.3	2.3
2.2	1.95	?	1.8	1.75	1.3	1.8	1.9	2.0	1.7	2.0	1.8
16.6	16.2	15.7	16.1	17.2	10.3	13.1	15.8	16.6	16.5	13.5	16.9
5.1	4.3	4.3	4.8	5.0	2.3	4.0	4.0	4.1	4.8	3.2	4.8
8.9	8.9	8.0	8.6	9.2	5.4	6.7	8.3	8.6	8.5	6.2	9.5
2.8	2.6	2.3	2.3	2.6	1.4	1.8	2.2	2.5	2.5	1.9	2.6
1.45	1.65	1.65	1.65	1.8	0.97	1.45	1.55	1.7	?	?	1.3
1.3	1.5	1.45	1.45	1.55	1.0	2.7	1.25	1.5	?	?	1.3
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
21.0	20.0	19.0	18.5	18.8	10.5	15.6	18.5	20.5	20.0	16.0	21.5
8.9	9.1	8.8	8.6	9.5	5.5	7.3	8.6	8.0	9.2	7.5	9.3
31.0	30.0	29.0	26.0	30.0	19.5	25.0	28.5	32.0	29.0	25.0	30.0

in centimetres.

CHIMÆRA OWSTONI N. SP. Pl. I., figs. 2 and 3.

Of this species I have seen only two specimens, a male and a female, in which rather a robust body, minutely lateral canal undulating, distinct and falcate anal fin, very deep anal notch, and brown color with more or less indistinct pale spots or blotches are characteristic points. Description in detail is as follows:

Head measured from tip of snout to first gill-opening (snout being rather shortened after preservation) equal to greatest height of body in front of the posterior end of the insertion of first dorsal; both contained $4\frac{3}{8}$ in total length exclusive of the parts behind the dorsal notch; height of head in front of insertion of pectoral a little less than height of body; the height in front of eye $1\frac{2}{3}$ in height of body; snout 2, eye $3\frac{3}{4}$, inter-orbital $4\frac{1}{7}$ in head. Spine of first dorsal curved backwards, its length equal to that of head, longer than the anteriormost ray of first dorsal, its anterior surface smooth, keeled in the median line, its posterior surface for a little less than half its length with recurved spinules as strong as those of *phantasma*; anteriormost ray of first dorsal exclusive of its fleshy base $1\frac{1}{3}$ in head; free margin of the fin almost straight, subcontinuous to second dorsal by a fold of rayless skin; the distance between origin of second dorsal and insertion of pectoral a little less than the distance between the latter and insertion of ventral; free margin of second dorsal may be either gently convex or concave as shown in the figure; its posterior margin rounded, continuous to caudal lobe with a deep notch. Anal low, falcate, its notch opposite the dorsal notch and very deep; lower lobe of caudal higher than the upper, the former extending further

posteriorly than the latter; each lobe of caudal nearly as high as in *mitsukurii*; no tail filament as in *purpurascens*; pectoral pointed and slightly falcate, its tip reaching far behind insertion of ventral when depressed; ventral truncate at the free margin, its inner margin rounded, its insertion midway between tip of head and dorsal notch.

Lateral canal with fine sinuation which is not so apparent as in *phantasma*; from the insertion of ventral backwards for some distance, the sinuation grows somewhat more pronounced; maxillo-mandibular and jugular branches of the canal system arise at the same point from the suborbital branch (Pl. II., figs. 8 and 10), or the latter directly from the suborbital at a point a short distance behind the maxillo-mandibular (Pl. II., fig. 2). Six rods in the anterior lamina of upper jaw; margin of the lamina sinuate and slightly convex; lateral rods behind the lamina low, oblique, their tips directed medianly. Each lamina of lower jaw with two concavities more or less sinuate in the margin. Peritoneum white; wall of the digestive canal whitish. The species has more a robust body than *jordani*.

There exists no difference in external features between the male and the female except in the sexual characters. Cephalic organ on the snout in front of eye, its inner surface armed with about seventy spinous denticles, its length $2\frac{1}{8}$ in eye length. Clasper tripartite, its length from insertion $1\frac{5}{8}$ in head, its division at a point about two thirds its length, its tip covered with fine shagreen skin; anterior ventral clasper with five spiny denticles on the median side.

Color in formalin dark brown, with lighter dot-like and elongate spots, often indistinctly vermiculate by the spots fusing together. This marking extends to head and to bases of pectoral

and ventral fins. On the side of body behind the ventral, three pale broad lines below the lateral canal and one above it. Dorsals, anal, caudal, and free margins of pectoral and ventral blackish; proximal parts of dorsals marked similarly as on the side of body; numerous transverse series of dark dots above the lateral canal on the side of body.

The male specimen here figured as the type is deposited in the museum of the Zoölogical Institute.

To sum up, the species has the following characters:—dusky coloration with lighter spots; great eye; rather robust body; spine of first dorsal with spinules as strong as those of *phantasma*, and projecting beyond the end of the anteriormost ray of first dorsal; large, pointed pectoral; no caudal filament; anal larger than that of *jordani*; lateral canal finely sinuate in the anterior part of body.

The species is named after Mr. OWSTON, the well-known naturalist of Yokohama.

MEASUREMENTS OF THE SPECIES.

	Male.	Female.
Total length (exclusive of parts behind dorsal notch)	71.0	69.0
Length from dorsal notch to end of caudal	? 22.5	14.5
Length of head (to first gill opening)	14.2	? 15.0
Height of head behind eye	12.6	13.1
Height of head in front of eye	11.1	11.9
Greatest height of body (in front of the posterior end of the } insertion of first dorsal).....	14.7	14.5
Long. diam. of eye.....	4.25	3.9
Diameter of pupil	1.8	1.8
Long. diam. of iris.....	3.6	3.0

	Male.	Female.
Length of snout	7.0	7.2
Interorbital width	3.4	3.5
Length of dorsal spine	15.8	? 12.6
Height of anteriormost ray of first dorsal (exclusive of its fleshy base)	11.2	10.9
Height of highest part of second dorsal (measured perpen- dicular to upper margin of body)	2.8	3.4
Upper margin of pectoral (excl. of its fleshy base)	20.5	19.2
Breadth of pectoral at insertion of base	5.5	5.1
External margin of ventral (exclusive of its fleshy base).....	11.9	10.9
Breadth of ventral at insertion of base	2.9	2.8
Height of upper lobe of caudal	1.4	1.35
Height of lower lobe of caudal	1.8	1.75
Length of cephalic organ	2.0	—
Length of clasper from its insertion	8.5	—
Length of clasper from insertion to the point of division...	5.2	—
Distance between insertion of pectoral and that of ventral...	24.0	24.0
Distance between insertion of the dorsal spine and that of } pectoral	11.6	10.3
Distance between base of ventral and anal notch	33.5	31.5

All the measurements are in centimetres.

*Synopsis of Species of Chimæra in the Waters
of Japan.*

I. Anal notch present. (With two dorsal fins. Claspers long, tripartite.)

a) Caudal filament present, moderate in length.

1) Distance between insertion of clasper and its point of division almost one half that between the latter and tip of clasper; spinous roughness of dorsal spine distinct; color silvery, with two longitudinal bands near

back, and one less distinct band along the lateral canal..... *phantasma*.

- 2) Distance between insertion of clasper and its point of division almost twice that between the latter and tip of clasper; spinous roughness of dorsal spine less distinct; anal notch deeper; color uniformly dark brown, with four indistinct bands in the posterior part of body..... *jordani*.

b) No caudal filament.

- 3) Distance between insertion of clasper and its point of division nearly twice that between the latter and tip of clasper; spinous roughness of dorsal spine as distinct as in *phantasma*; anal notch deeper than in *jordani*; color brown, distinctly marbled with small pale spots, with four indistinct lighter bands in the posterior part of body..... *owstoni*.

II. No anal notch. (Two dorsal fins.)

a) Claspers rather short, bipartite. Caudal filament very long.

- 4) Point of division of clasper in the middle of its length; spinous roughness of dorsal spine rather indistinct; color whitish with dusky parts here and there *mitsukurii*.

b) Claspers long, tripartite. No caudal filament.

- 5) Distance between insertion of clasper and its point of division nearly twice that between the latter and tip of clasper; spinous roughness of dorsal spine very indistinct; color uniformly deep purple... *purpurascens*.



S. TANAKA.

ON TWO NEW SPECIES OF CHIMÆRA.

PLATE I.

Explanation of Plate I.

- Fig. 1. Lateral view of *Chimæra jordani* N. SP. About $\frac{2}{5}$ nat. size.
- Fig. 2. Lateral view of *Chimæra owstoni* N. SP. About $\frac{2}{5}$ nat. size.
- Fig. 3. Ventral view of the elaspers of *Chimæra owstoni*. About $\frac{2}{3}$ nat. size.
- Fig. 4. Ventral view of the elaspers of *Chimæra phantasma* JORDAN & SNYDER. About $\frac{2}{3}$ nat. size.

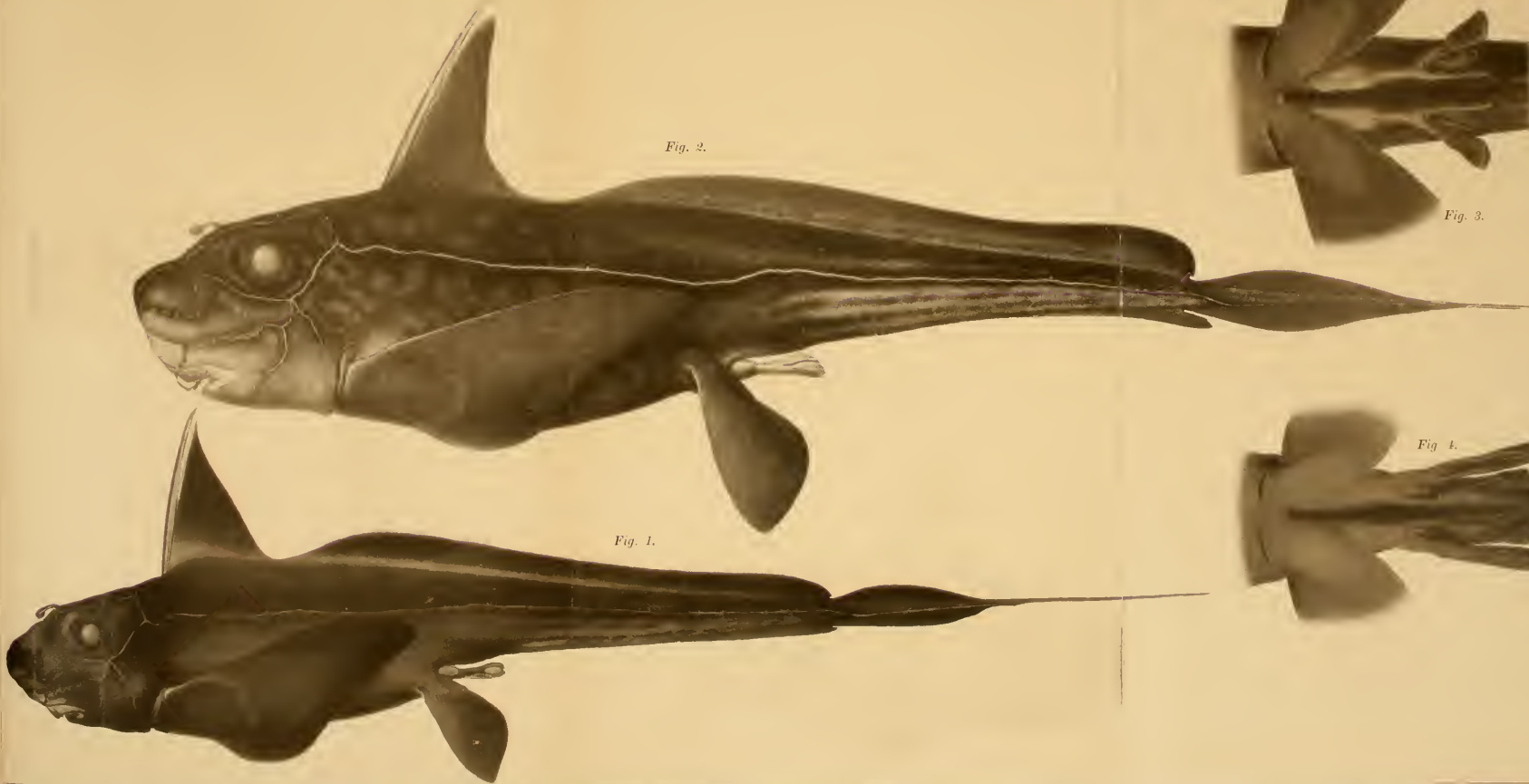


Fig. 2.

Fig. 3.

Fig. 1.

Fig. 4.

S. TANAKA.

ON TWO NEW SPECIES OF CHIMÆRA.

PLATE II.

Explanation of Plate II.

Course of the sensory canal system in the *Chimæra* of Japan. All the lines have been traced on paper placed on the specimens themselves.

Figs. 1-4. Several parts of the canal system taken successively from anterior parts of the left side of *Chimæra purpurascens*. Fig. 3. Lateral canal above insertion of ventral fin.

Fig. 5. Anterior part of the canal system on the left side of another specimen of *purpurascens*.

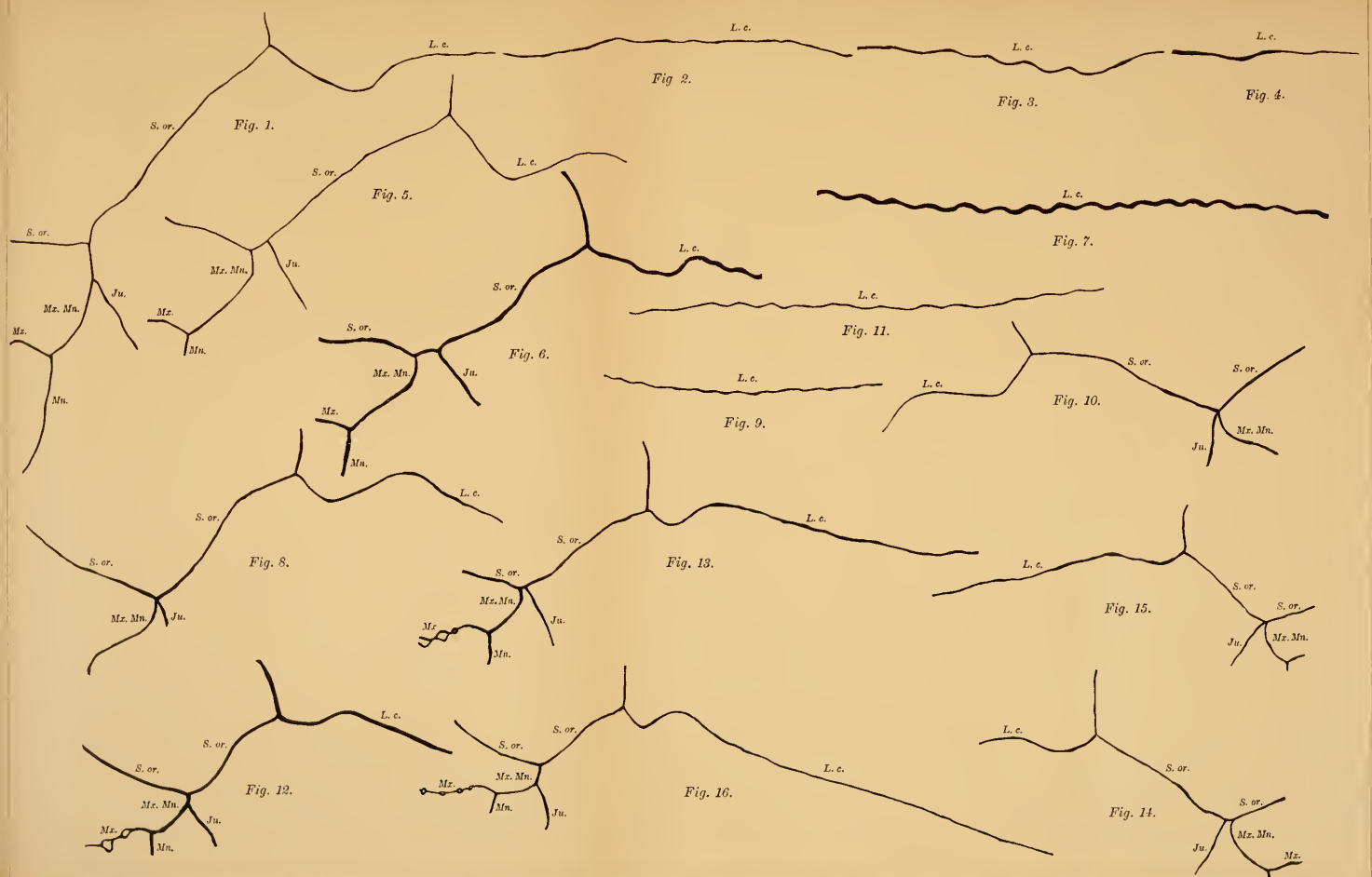
Figs. 6-7. Anterior parts of the canal system on the left side of *Chimæra phantasma*.

Figs. 8-9. Anterior parts of the canal system on the left side of *Chimæra oustoni*.

Figs. 10-11. Anterior parts of the canal system on the right side of the same individual as above.

Figs. 12-15. Anterior parts of the canal system in four individuals of *Chimæra jordani*.

Fig. 16. Anterior parts of the canal system on the left side of *Chimæra mitsukurii*.



A Revised List of Corallinæ.

By

K. Yendo, *Rigakushi*.

SYNOPTICAL KEY TO THE GENERA.

- A.** Mother cells of the propagating cells generated in the cortex: genicula unizonal or multizonal: articuli cylindrical, compressed or sagittate: ramification dichotomous, pinnate or irregular. Conceptacles verrucose, hemispherical or conical, sessile.....*Gen. I. Amphiroa.*
- I.** Medullary portion of articuli constructed with several zones of articoli interposed between zones of otricoli.
- a. Articuli cylindrical, irregularly branching. Genicula multizonal rarely unizonal, lineæform.....*Sect. I. Euamphiroa.*
- b. Articuli compressed or subcompressed, mostly dichotomously branching. Genicula multizonal, mostly fenestraform in younger portion, bandform in older portion.....*Sect. II. Eurytion.*
- II.** Medullary portion of articuli constructed with zones of articoli.
- a. Articuli compressed sagittate, reniform, or truncate, pinnately branched; genicula unizonal, lineæform. Conceptacles on the surface of the compressed articuli.....*Sect. III. Arthrocardia.*
- b. Articuli cylindrical or compressed sagittate, or linear, pinnately or irregularly branched. Conceptacles conical or hemispherical, prominent on the margins of the compressed articuli, or on the surface of cylindrical articuli.....*Sect. IV. Marginisporum.*
- B.** Mother cells of the propagating cells generated in the medulla; genicula unizonal or multizonal; articuli cylindrical, compressed, sagittate or truncate; ramification pinnate, dichotomous, verticillate or irregular. Conceptacles verruculose, globular or pear-shaped.
- I.** Genicula multizonal; ramuli starting from the genicula.
- a. Articuli cylindrical, ramuli verticillate.....
.....*Gen. II. Metagoniolithon.*
- b. Articuli flat, di-trichotomously branching *Gen. III. Litharthron.*

- II. Genicula not specially differentiated; main branches dichotomously divided, with compressed articuli; ramuli pinnate, with cylindrical articuli *Gen. IV. Lithothrix.*
- III. Genicula unizonal, ramuli starting from articuli.
- a. Conceptacles sessile immersed in articuli or pinnulets *Gen. V. Cheilosporum.*
- i. Fertile articuli sagittate with pointed wings, conceptacles immersed in the upper margins of the sagittate articuli *Sect. I. Eucheilosporum.*
- ii. Fertile articuli sagittate or reniform with round or truncate wings, conceptacles immersed in the outer margins of the articuli, or in the surface of the articuli *Sect. II. Alatocladia.*
- iii. Articuli compressed hexagonal, conceptacles wartlik, on the surface of the articuli or immersed in the pinnulets *Sect. III. Serraticardia.*
- b. Conceptacles stalked, mostly taking the place of a segment.
- i. Branches pinnated *Gen. VI. Corallina.*
- a. Pinnules simple or less decompound *Sect. I. Officinales.*
- β. Pinnules densely decompound *Sect. II. Halyption.*
- ii. Branches dichotomous *Gen. VII. Jania.*

SPECIAL PART.

Gen. I. AMPHIROA LAMX.

Sect. I. EUAMPHIROA DCNE. Mémoir. p. 111.

Amphiroa anastomosans W. v. B. Coral. Sib. Exp. p. 91. Pl. 16. fig. 3-4.

A. valonioides YENDO. Coral. ver. Jap. p. 5. Pl. 1. fig. 1-3; Pl. IV. fig. 1.

A. fragilissima f. *fragilissima* W. v. B. Coral. Sib. Exp. p. 90.

= *Amp. fragilissima* LAMX. Exp. Method. p. 26. t. 21. fig. d.

= *Cor. fragilissima* ELLIS et SOL. Coral. p. 123. Tab. 21. fig. 9.

= *Amp. debilis* KÜTZ. Spec. p. 700. no. 3.

= *Cor. rigens* PALL. Elench. Zooph. p. 429. no. 11.

- A. fragilissima f. cuspidata** W. v. B. Coral. Sib. Exp. p. 90.
 = *Amp. cuspidata* LAMX. Exp. Method. p. 26. t. 21. fig. f.
 = *Cor. cuspidata* ELLIS et SOL. Coral. p. 124. tab. 21.
 = *Amp. fragilissima* KÜTZ. (nec LAMX.) Spec. p. 700. no. 2.
- A. fragilissima f. cyathifera** W. v. B. Coral. Sib. Exp. p. 90.
 = *Amp. cyathifera* LAMX. Freyc. Voy. Zool. p. 627.
- A. cryptarthrodia** ZANARD. Coral. p. 21.
- A. involuta** KÜTZ. Tab. Phyc. VIII. p. 23. Tab. 48. fig. 2.
- A. rigida** LAMX. Histoir. p. 297. t. 11. fig. 1.
 = *Amp. cladoniaeformis* MENEGH. in KÜTZ. Spec. p. 700.
 = *Amp. spina*, KÜTZ. Spec. p. 701.
 = *Amp. irregularis* KÜTZ. l. c.
 = *Amp. amethystina* ZANARD. Coral. p. 211.
 = *Amp. spina* β *amethystina* KÜTZ. p. 700.
- A. rigida var. inordinata** ZANARD. Iconogr. III. p. 265. Tab. 99. B. fig. 5.
 = *Amp. inordinata* ZANARD. Coral. p. 21.
- A. tribulus** LAMX. Histoir. p. 302.
 = *Coral. tribulus* ELLIS et SOL. Coral. p. 124. Tab. 21.

Amphiroa fragilissima has its articuli much swollen at their distal ends. That this character is also found in *Metagoniolithon* (*Amphiroa*) *Charoide* and *Metag. stelligerum* has been remarked by ARESCHOUG.¹⁾ MADAM WEBER VAN BOSSE²⁾ has clearly illustrated the structure in her recent work. The intumescence is evidently due to the secondary growth of the circumgenicular cortex as was formerly proven by me in the case of *Metag. stelligerum*.³⁾ I had an opportunity of examining only of the specimen of *Amp. fragilissima* LAMX. kept in the herbarium of the Higher Normal School of Tokyo. The specimen is in a much distorted condition with most of the articuli separated one from another.

According to MADAM WEBER VAN BOSSE the plant has in its internal structure no less a tendency to approach to *Meta-*

1) Sp. Alg. II. p. 531.

2) Coral. of Siboga Exp. Pl. XVI. fig. 2, 5.

3) Study of Genicula. p. 29.

goniolithon and *Litharthron*. But we can not find good reason to separate the species in question from the present genus and bring it into either of these two genera.

The characters which distinguish the present section from the next are rather ambiguous. Some of the members of the *Eurytion* gradually approach this section in shape of articuli and in ramification. Yet it is often convenient to reserve the name to represent the cylindrical *Amphiroa*.

Sect. II. **EURYTION** DCNE. *Mémoire*, p. 113.

- A. nodulosa** KÜTZ. *Tab. Phyc.* VIII. p. 19. *Tab.* 41. fig. 1.
- A. verruculosa** KÜTZ. *Phyc. Gen.* p. 387. *Tab.* 79. fig. 3.
= *Amp. cryptarthrodia* β *verruculosa* HAUCK. *Meeresalg.* p. 276.
- A. Beauvoisii** LAMX. *Histoire*, p. 299.
= *Amp. exilis* HARV. *Ner. Austr.* p. 95.
- A. Beauvoisii** β *crassiuscula* (HARV.) †
= *Amp. exilis* β *crassiuscula* HARV. *Ner. Austr.* p. 95.
- A. zonata** YENDO. *Cor. ver. Jap.* p. 10. *Pl.* 1. fig. 11–14. *Pl.* IV. fig. 9.
- A. parthenopea** ZANARD. *Iconogr.* III. p. 268. *Tab.* 100. B.
- A. echigoensis** YENDO. *Cor. ver. Jap.* p. 11. *Pl.* 1. fig. 15–16; *Pl.* IV fig. 10.
- A. ephedræa** DCNE. *Mémoire*, p. 112.
 - α **fusoides** (ARESCH.) †
 = *Amp. fusoides* LAMX. *Histoire*, p. 298. t. 11. fig. 2.
 = *Amp. Pöppighii* ENDL. et DIES. *Alg. Natal.* p. 290.
 = *Amp. ephedræa* HARV. *Ner. Austr.* p. 95. t. 39.
 = *Amp. ventricosa* LAMX. (sec. DCNE. *Mémoire* p. 112.)
 - β **Gaillonii** (ARESCH.) †
 = *Amp. Gaillonii* LAMX. *Histoire*, p. 298. t. 11. fig. 3.
 = *Amp. Guenzii* HARV. *Ner. Austr.* p. 95.
 = *Cor. ephedræa* LAMX. *Mem. Mus.* II p. 238.
 = *Cor. Chara* γ LAMX. (sec. DCNE. *Mémoire*, p. 112.)
- A. anceps** DCNE. *Mémoire*, p. 113.
 - = *Cor. anceps* LAMX. *Mem. Mus.* I. p. 238.
 - = *Cor. dilatata* LAMX. *Histoire*, p. 299.
 - = *Amp. dilatata* ARESCH. in *J. Ag. Spec.* II. p. 536.
 - = *Amp. galaxauroides* SOND. *Plant. Preiss.* Vol. II. p. 188.

- = *Amp. Cumingii* RUPR. (sec. WEBER VAN BOSSE. Coral. Sib. Exp. p. 93.)
- = *Amp. Karstalskii* RUPR. ditto.
- = *Amp. nobilis* KÜTZ. Spec. p. 703. (sec. WEBER VAN BOSSE. l. c.)
- = *Amp. ephedraea* HARV. New South Wales Algæ. no. 458. (sec. WEBER VAN BOSSE. l. c.)
- A. Bowerbankii** HARV. Ner. Austr. p. 97. t. 37.
 - = *Amp. dilatata* KRAUSS. Flora des Cap. u. Natal. p. 206. (sec. ARESCH.)
- A. crassa** LAMX. Freye. Voy. Zool. p. 627.
 - f. **Godeffroyi** W. v. B. Coral. Sib. Exp. p. 98.
 - = *Amp. Goddefroyi* GRUN. Alg. d. Fidschi.
 - f. **minuta** W. v. B. Coral. Sib. Exp. p. 98.
- A. foliacea** LAMX. Freye. Voy. p. 628. t. 93. fig. 2-3.
 - = *Amp. squarrosa* GRUN. in Bot. Herb. Hamburg. (sec. WEBER VAN BOSSE.)
 - f. **procumbens** W. v. B. Coral. Sib. Exp. p. 92.
 - f. **erecta** W. v. B. l. c.
 - = *Amp. nobilis* HAUCK. (nec. KÜTZ.) Ueber einige von Hildebr. Gesam. Alg. (sec. W. v. B.)
- A. pusilia** YENDO. Cor. ver. Jap. p. 13. Pl. I. fig. 22-23 : Pl. V. fig. 11-13.
- A. misakiensis** YENDO. l. c. p. 14. Pl. I. fig. 24-25 : Pl. VI. fig. 1.
- A. canaliculata** MART. Preus. Exp. Tange. p. 29. Pl. VI.

SPECIES DOUBTFUL.

- Amphiroa linearis* KÜTZ. Tab. Phyc. VIII. p. 22. Tab. 46. fig. 2.
- A. algeriensis* KÜTZ. Tab. Phyc. VIII. p. 21. Tab. 44. fig. 2.
- A. Boviesii* KÜTZ. l. c. p. 21. Tab. 43. fig. 4.
- A. pustulata* MART. in Reg. Flor. no. 31. (sec. ARESCH. in J. Ag. Sp. II. p. 535.)
- A. brasiliانا* DCNE. Mémoire. p. 113.
- A. complanata* KÜTZ. Phyc. Gen. p. 388.
- A. canaliculata* YENDO (nec MART.) Cor. ver. Jap. p. 14. Pl. I. fig. 26 : Pl. IV. fig. 14-15.
- A. Cumingii* MOST. Zellenpl. auf den Philippin. p. 660.

The essential characters of this section in distinction from those of the others lie in the regularity of the dichotomous ramification and the flatness of the articuli in the middle and upper portions. In *Amphiroa canaliculata* MART. and some others the dichotomy is more or less disturbed. The articuli of the species in this

section are mostly linear, but subterete in some species; in this respect gradually approaching the preceding section. *Amp. nodulosa* has nearly cylindrical articuli, slightly compressed in the ultimate articuli. *Amp. canaliculata* MART. has essentially broad and ancipitous articuli at the upper portions of the fronds. Both margins, however, are inflexed very much to one side forming a pair of canals along the margins. This is found to be the case in some other species, though in a slight degree, such as *Amp. foliacea* and *Amp. misakiensis*.

Some of the members, such as *Amp. Bowerbankii*, *Amp. anceps*, *Amp. canaliculata* MART., *Amp. foliacea*, etc., are habitually decumbent. This causes the differentiation of dorsiventrality in the upper articuli. The canaliculated species have the canals at the ventral side only, or in other words, on the shaded side: and the conceptacles are to be found on the dorsal side only. In the uncanaliculated and decumbent members the conceptacles are restricted to the shaded surface with a few conceptacles occasionally found on the opposite side. In the erect forms they are found on both surfaces.

The decumbent habit may have been caused by the fact that the genicula of the basal portion in these species develop further and finally form large horny flexible joints. These joints, i. e., the bandform genicula, allow the upper portions of the fronds to bend downwards. In the preceding section the lower genicula are very short and form the constrictions of the moniliform stems at the basal portions of the fronds. The short linear genicula cause the fronds to stand upright.

Amp. anceps DCNE., according to HARVEY's description and illustrations,¹⁾ is identical with *Amp. dilatata* ARESCH. ARESCHOU

1) Ner. Austr. p. 98. t. 37.

chose to mention them separately. MADAM WEBER VAN BOSSE is of the same opinion as HARVEY; and this view I think preferable. *Amp. Cumingii* RUPR. and *Amp. Karstalskii* RUPR. have been challenged by ARESCHOUG, who thought that they have close affinity with *Amp. exilis* HARV. MADAM WEBER VAN BOSSE has kindly written me after examination of authentic specimens that RUPRECHT's plants are identical with *Amp. anceps*. This disposal of RUPRECHT's species is entirely on her own authority.

ARESCHOUG doubtfully referred *Amp. Beauvoisii*, *Amp. pustulata* and *Amp. complanata* to *Amp. exilis* HARV. MADAM WEBER made it clear that HARVEY's plant was similar to *Amp. Beauvoisii* LAMX. The other doubtful species described by KÜTZING are so insufficiently defined that I can not find their exact relation to other plants; nor are they sharply enough defined to be reckoned as independent species. MADAM WEBER remarks that she saw in KÜTZING's herbarium a plant called *Amp. linearis* Kütz. which she thinks a stunted form of *Amp. ephedra* LAMX. She does not mention anything about the connection between the specimen and the illustration in KÜTZING's Tab. Phyc. VIII. Tab. 46. *Amp. canaliculata* YENDO is a doubtful plant, as has been already mentioned.¹⁾ It is probably a broad form of *Amp. anceps*. The scarcity of the specimen precludes me from further discussion.

Set. III. **ARTHROCARDIA** DCNE. p. p. Mémoir. p. 112.

= *Arthrocardia* ARESCH. p. p. in J. AG. Spec. Alg. II. p. 547.

= *Pseudarthrocardia* YENDO. Enumer. Cor. Alg. p. 191.

Amphiroa corymbosa DCNE. Mémoir. p. 112.

1) Enumeration of Coral. Alg. p. 190.

- = *Arthrocardia corymbosa* ARESCH. in J. Ag. Spec. Alg. II. p. 550.
- = *Corallina magnifica* LEACH. (sec. Harv. Ner. Austr. p. 99.)
- α. ARESCH. in J. AG. Spec. Alg. II. p. 551.
- = *Corallina corymbosa* LAMK. Mem. Mus. II. p. 234.
- β. ARESCH. in J. AG. Spec. Alg. II. p. 551.
- = *Ampiroa corymbosa* HARV. Ner. Austr. p. 99. t. 38.
- A. aberrans** YENDO. Cor. ver. Jap. p. 16. Pl. I. fig. 1-5: Pl. V. fig. 1-3.
- A. Wardii** HARV. Ner. Austr. p. 99. t. 38.
- = *Arthrocardia Wardii* ARESCH. in J. AG. Spec. Alg. II. p. 551.
- A. Mallardiæ** HARV. Ner. Austr. p. 99.
- = *Arthrocardia Mallardiæ* ARESCH. in J. AG. Spec. Alg. II. p. 552.

SPECIES DOUBTFUL.

- Corallina rigida* Kütz. Spec. p. 708.
- Amphiroa constricta* Kütz. Tab. Phyc. VIII. p. 24. Tab. 49. fig. 3.
- Corallina gomphonemacea* Kütz. l. c. p. 30. Tab. 63. fig. 1.
- Corallina frondescens* Kütz. (nec POST et RUPE.) l. c. p. 29. Tab. 59. fig. 2.
- Corallina arbuscula* Kütz. (nec POST. et RUPE.) l. c. fig. 3.

Arthrocardia was first established by DECAISNE as the second section of the genus *Amphiroa*. ARESCHOUG elevated it to a distinct genus. Both writers enumerated two differing groups under a single section or genus. It is regrettable that SCHMITZ, when he united *Arthrocardia* ARESCH. with *Chilosporum*, did not recognize this confusion. MADAM WEBER re-established *Arthrocardia* ARESCH. She seems to have overlooked the peculiarities in the position of the conceptacles of those species such as *Cheilosporum frondescens*, *Cheil. yessæense*, etc., which are enumerated under the section *Alatocladia* in the present paper. In distinguishing *Arthrocardia* from *Cheilosporum* she states: "The position of the conceptacula, however, marks a difference between the genera: in *Arthrocardia* we find conceptacula on the joint as in *Amphiroa*; in *Cheilosporum* we find them immersed in the margin of the broadened, wing-like joint....." This distinction holds good

only for separating the above listed species from the section *Eucheilosporum*.

I am not inclined to discuss the question whether *Arthrocardia* is worthy of generic rank or not. Were the characters of *Arthrocardia* important enough to elevate it to a genus, the *Marginisporum*, the *Alatocladia* and the *Serraticardia* should be equally mentioned as genera. But this is a matter of personal preference.

I was no less in doubt whether the two species, *Amp. Wardii* and *Amp. Mallardiae*, described by HARVEY, should be legitimately reckoned under the present section or not. We have no information about the conceptacles of these species; and I was not so fortunate as to study authentic specimens. Judging, however, from the original descriptions and ARESCHOUG's notes, I ventured to arrange them as above. They may have close affinity with the *Serraticardia*.

Arthrocardia palmata ARESCH. seems to be unsatisfactorily defined. ARESCHOUG considers *Cor. filicula* LAMK. to be its forma. But the latter belongs without doubt to the *Alatocladia*, while the former has several characters allied to *Amp. aberrans*. GRUNOW¹⁾ remarks that *Cor. flabellata* KÜTZ. seems closely related to *Arth. palmata* ARESCH. As it is impossible at present to study original specimens of these species, I must satisfy myself with the references of these noted algologists.

The genicula of *Amp. aberrans* are formed of single zones of the periclinal cells. In explaining the fig. 5. pl. II. of "Cor. ver. Jap.," I remarked that probably the geniculum was built up with several zones. This was disproved after repeated closer examination.

1) Weltreise der Novara p. 79.

Sect. IV. MARGINISPORUM YENDO. Enumer. Cor. Jap. p. 191.

Amphiroa declinata YENDO. Cor. ver. Jap. p. 15. Pl. I. fig. 29; Pl. VI. fig. 4.

A. crassissima YENDO. l. c. p. 16. Pl. I. fig. 27–28; Pl. V. fig. 5–6.

A. cretacea ENDL. Mantissa. Suppl. III. p. 49.

= *Corallina cretacea* POST. et RUPR. Illustr. p. 20. t. 40. f. 104.

= *Arthrocardia cretacea* W. v. B. Coral. Sib. Exp. p. 105.

f. rosariformis YENDO. Cor. ver. Jap. p. 7. Pl. IV. fig. 3.

f. capensis †

= *Amphiroa capensis* ARESCH. in J. AG. Spec. Alg. II. p. 533.

= *Amp. dubia* KÜTZ. Tab. Phyc. VIII. p. 24. Tab. 49. fig. 1.

var. tasmanica KÜTZ. Tab. Phyc. VIII. p. 23. Tab. 47. fig. 2.

= *Amp. tasmanica* SOND. Plant. Müll. p. 686.

f. breviarticulata. †

= *Amp. breviarticulata* ARESCH. in J. AG. Spec. Alg. II. p. 532.

SPECIES DOUBTFUL.

Amphiroa lucida LAMX. Histoïr. p. 297.

Amp. nodularia DCNE. Mémoir. p. 111.

= *Corallina nodularia* LAMX. (sec. DCNE. Mémoir. p. 111.)

= *Cymopolia rosarium* LAMX. (do.)

= *Corallina rosarium* LAMK. Mém. Mus. I. p. 234.

The first two species which are assigned to the Japan coast only, have a peculiarity in the position of the conceptacles, which are always found on the margins of the articuli, growing in a row, pointing obliquely toward the ventral side of the frond. In other respects, these species are closely related to the preceding section.

MADAM WEBER transferred *Amp. cretacea* ENDL. to *Arthrocardia* ARESCH. The principal reason for doing so seems to be grounded on the internal structure of the articuli. In the external appearance of the articuli the species suggests a position near to *Amp. rigida* LAMX. or *Cheilosporum tuberculosum*. From the former it is distinguished by the unizonal genicula and the

superficial position of the conceptacles; and from the latter by the cortical origin of the mother cells of the spores.

I am no less in doubt in classifying *Amp. cretacea* ENDL. in the same section with *Amp. declinata*. The position of the conceptacles is very irregular in the former species, while in the latter the conceptacles are arranged in a definite regularity. *Amp. cretacea* and its forms are widely distributed in the colder seas of both the northern and the southern hemispheres. It may claim an independent position. The above disposition is a provisional one until we find a more special character in *Amp. cretacea*.

Amp. breviarticulata ARESCH. and *Amp. capensis* ARESCH. seem to be nearly allied to *Amp. cretacea* ENDL. According to the descriptions given by ARESCHOUG¹⁾ we can hardly distinguish the former from *var. tasmanica* KÜTZ. This has been already noted by SONDER.²⁾ *Amp. capensis* ARESCH. is also unseparable from *Amp. cretacea*., except that the basal genicula are comparatively longer. *Amp. dubia* KÜTZ., judging from the figures of Tab. Phyc. VIII. Tab. 49. fig. 1., is referrible to *Amp. capensis* ARESCH. These species have hitherto been distinguished by the relative size and forms of the articuli; but these points can hardly be relied upon to warrant a specific character.

MADAM WEBER doubts *Amp. breviarticulata* ARESCH. She found an *Arthrocadia* called by that name in SURINGAR's herbarium, and tried in vain to see the type of ARESCHOUG's species. Judging from the original descriptions, I believe the specimen found by her is different from what ARESCHOUG meant.

Amp. cretacea has been defined as often having recurved or flexuous articuli. ARESCHOUG put too much stress on this character

1) Spec. Alg. II. p. 532.

2) Linnea. XXV. p. 687.

in distinguishing his two species. In the specimens which I have referred to *Amp. cretacea* ENDL., found commonly in north Japan, the articuli with such characters occur frequently but not invariably. Neither ARESCHOUG nor KÜTZING gives anything about the conceptacles of their plants, and I have not seen any authentic specimens of these species. But the distinguishing characters mentioned by these authors are by no means fixed ones. Their species, if worth mentioning separately, may be disposed as above.

Amp. nodularia DCNE., according to ARESCHOUG, has close affinity with *Amp. breviarticulata*. It should be united with *Amp. cretacea* or its forma.

Gen. II. METAGONIOLITHON W. v. B.

Metagoniolithon Charoides W. v. B. Coral. Sib. Exp. p. 84.

- = *Amphiroa Charoides* LAMX. Histoir. p. 301.
- = *Amp. Chara* DCNE. Classif. des Alg. p. 63. Pl. 17. fig. 9.
- = *Corallina Galioides* LAMK. Mem. Mus. II. p. 239.
- = *Amp. stellulata* Kütz. Spec. p. 702.

M. stelligerum W. v. B. Coral. Sib. Exp. p. 84.

- = *Amp. stelligera* ARESCH. in J. AG. Spec. Alg. II. p. 540.
- = *Corallina stelligera* LAMK. Mem. Mus. II. p. 239.
- = *Amp. jubata* LAMX. Histoir. p. 301. t. 11. fig. 6.
- = *Amp. elegans* SOND. Plant. Preiss. p. 55. no. 53.
- = *Amp. verrucosa* LAMX. Histoir. p. 300. Pl. XI. fig. 4.
- = *Amp. stelligera* β . *interrupta* Kütz. Tab. Phyc. VIII. p. 26. Taf. 52. fig. h.
- = *Amp. interrupta* LAMX. Histoir. p. 301. Pl. XI. fig. 5. A.

M. gracile †

- = *Amp. gracile* HARV. Phyc. Austr. Pl. CCXXXI.
- = *Amp. intermedia* HARV. Syn. Catal. of Austr. and Tasm. Alg. p. 30.

SPECIES DOUBTFULL.

- Amphiroa granifera* HARV. Syn. Catal. of Austr. and Tasm. Alg. p. 30.
- = *Metagoniolithon graniferum* W. v. B. Coral. Sib. Exp. p. 84.

- = *Amp. setacea* KÜTZ. Spec. p. 700.
= *Amp. similis* SOND. (see WEBER l. c. p. 84.)
Corallina Chara LAMX. Mem. Mus. I. p. 240.
Cor. radiata LAMX. Mem. Mus. I. p. 240.

This genus is easily distinguished from the others by having verticillate ramuli which start from genicula and not from articuli. The articuli are exclusively cylindrical, varying in their length according to the position in a frond and to the species. In some species, both extremities of the articuli bulge out, owing to the secondary development of the circumgenicular cortex; and in some species the verticillate ramuli are slightly curved upward and inward.

The conceptacles are, as far as I could observe from the accessible material, generated from the medullary cells. The diameter of the conceptacles is very large when compared with that of the ramuli; in *Metagoniolithon stelligerum* the former is subequal to the latter. This circumstance, no doubt, forces conceptacles to start from the deep places in the medulla.

The species under this genus are characterised by much elongated genicula. In *Metag. stelligerum* the length of a matured geniculum often attains more than twenty times its breadth, and the greater portion of the rachis is formed by the genicula. These genicula, quite strange in comparison with those of plants belonging to other genera, can send out the verticillate ramuli around a certain region. No ramuli is found starting directly from an articulus. This peculiarity, together with the medullary origin of the propagating cells, is enough to detach the present group from the genus *Amphiroa* and to place it under a new one. In my former paper I made a preliminary announcement of this matter. A few months later, MADAM WEBER, evidently

not knowing what I had suggested, established a new genus for this peculiar species.

HARVEY remarks that *Amp. gracilis* HARV. has some affinity with *Metag. stelligerum*, and still closer affinity with *Amp. intermedia* HARV. Cf. Phyc. Austr. t. 231. I consider that both of HARVEY'S plants belong to the same species. MADAM WEBER refers *Amp. granifera* to the genus *Metagoniolithon* reducing *Amp. intermedia*, *Amp. setacea*, *Amp. similis* and *Amp. stellata* to the position of its sponymines. I can not decide at present whether *Amp. granifera* HARV. is the same as *Amp. gracilis* or not. If it be the same, the name *Amp. gracilis* HARV. should be kept on account of priority. *Amp. similis* SOND. was united by MADAM WEBER to *Metag. graniferum*. But I could not find the description in Bot. Zeitung 1845, which she mentioned as the "quelle" of *Amp. similis* SOND.

Gen. III. LITHOTHRIX J. GRAY.

Lithothrix aspergillum J. GRAY. Journ. Bot. Vol. V. p. 33.

= *Amphiroa aspergillum* ANDERSON. Zoe. II. p. 225.

= *Amp. nodulosa* FARL. (nec KÜTZ.) Report U. S. Fish. Comm. 1875. p. 715.

= *Amp. nodulosa* COLL., HOLD. et SETCH. Phyc. Bor.-Amer. no. 498.

f. nana †

= *Amp. aspergillum f. nana* SETCH. et GARD. Alg. N. W. A. p. 359.

The monotypic genus has been established by J. GRAY, who does not, however, give clear reason for its establishment. But it is not difficult to understand from his remarks that the plant has some relation to *Amphiroa* by having wartlike conceptacles and at the same time to *Corallina* in its general habit. The generic diagnosis given by him is not sufficient to separate it from the other genera. The plant was referred to *Amphiroa* by AN-

DERSON¹⁾ without any comment, but probably strengthened by PROF. FARLOW's remark on this species.^{2)*}

It has, however, unique characters not mentioned by its discoverer or others, as far as my research has extended. The peculiarity lies in the genicular structure and in the branching mode of the fronds. It has no geniculum, in the exact sense, similar to any of the other *Corallinæ*. The geniculum is formed by the lower half portions of the filamentous periclinal cells, the upper half of which practically corresponding to the medulla of other species. The details are given in my former paper.³⁾ The axial stems ramify dichotomously while the ramuli start from the margins of the articuli of the stem. An articulus which sends forth dichotomous branches from its top has a longitudinal furrow along its median. Hence the articulus apparently seems to be two compressed articuli fused together by their periclinal sides with a geniculum on the top of each. The furrow or the canalization is also visible in the succeeding lower articuli, gently disappearing as we trace downwards. The two genicula on the top of the branching articulus are not in a straight line but form a geometrical supplementary angle to the axile divergence of the branches. The angulation of the genicula is also distinct in the succeeding articuli, but gradually approaches a straight line as canalization vanishes.

The canalization and the mode of pinnation of ramuli are unique characters among *Corallinæ*. The solitary conceptacles on

1) Zoe. Vol. II. p. 225.

2) Proc. of Amer. Acad. Vol. XII. p. 239.

* These two papers were not accessible to me. But finding them indispensable in preparing the present chapter, I asked MR. F. S. COLLINS for references. MR. COLLINS was so kind as to send me a transcript of all the lines relating to the subject. I desire to express to him my heartiest thanks.

3) Study of Genicula. p. 16.

the articuli of branchlets are also an unusual phase. These characters are ample enough to restore the genus, with slight modification in the original diagnosis. This was also mentioned in my former paper and noticed by MADAM WEBER.

Gen. IV. **LITHARTHRON** W. v. B.

? *Rhodopeltis* SCHMITZ. p. p. in ENG. Pflanzenfamil. Alg. p. 530.

Litharthron australe W. v. B. Coral. Sib. Exp. p. 104.

= *Amphiroa australis* SOND. Plant. Preiss. p. 55.

? = *Rhodopeltis australis* SCHMITZ (nec HARV.) p. p. in ENG. Pflanzenfamil. Alg. p. 530.

Conceptacles have not yet been found in this species, which has, however some relation to *Metagoniolithon* in the structure of genicula and the mode of ramification. It was regarded by some old writers as having close affinity with *Eurytion*. But this is merely a superficial likeness in the shape of the articuli. A study of the internal structure proves that it is an independent genus.¹⁾ KÜTZING²⁾ tended toward this view but did not actually appropriate it.

HARVEY³⁾ described a nemathecium-like plant, calling it *Rhodopeltis australis*, epiphytic on *Litharthron australe*. SCHMITZ⁴⁾ seems to have regarded the epiphyte to be the propagating organ of the host, which he classified among *Rhizophyllidaceæ*. MADAM WEBER has written me that PROF. DE TONI called her attention to this matter. It is also mentioned by DE TONI⁵⁾ in the last

1) After the publication of "Study of Genicula" MR. REINEOLD was so kind as to send me a piece of the original specimens of *Amp. australis* SOND. The specimen was of great value in preparing the present paper. I am very glad to express my gratitude to him.

2) Tab. Phyc. VIII. p. 25.

3) Phyc. Austr. Pl. 264.

4) ENGL. u. PRANTL: Pflanzenfamilien. Alge. p. 530.

5) Serie. XV. p. 175.

October number of *La Nouva Notarisia*. MADAM WEBER doubts SCHMITZ's view. So do I. The problem is reserved for future until an authentic specimen of *Rhodopeltis australis* or a fertile exemplar of *Litharthron australe* has been examined.

Gen. r. **CHEILOSPORUM** ZANARD. emend.

The genus *Cheilosporum* was first instituted by ZANARDINI to include most of the members of DECAISNE's fourth division of *Amphiroa*. SCHMITZ¹⁾ extended the generic sense so as to cover the genus *Arthrocardia* ARESCH. The definition of *Arthrocardia* given by ARESCHOUG is somewhat different from that of the section *Arthrocardia* DCNE. Many of the members of *Arthrocardia* ARESCH. may more legitimately be referred to *Amphiroa* than to *Cheilosporum*. On the contrary, the greater number of species comprised in the section *Arthrocardia* DCNE. evidently belong to *Cheilosporum*. Hence the genus *Cheilosporum*, as conceived in the present paper, comprises both the sections *Arthrocardia* DCNE. *p.p.* and *Cheilosporum* DCNE. The scope given by me to the genus thus practically agrees with that given by SCHMITZ, except that some species of *Arthrocardia* ARESCH. have been removed from it.

The members enumerated under the present genus show certain characters by which they may be easily distinguished from those of the other genera. The most important characteristic lies in the fact that the spores are situated deep in the medullary portion.

The genus is divided into three sections, viz., *Eucheilosporum*, *Alatocladia* and *Serraticardia*. The *Eucheilosporum* is a group

1) System. Uebersicht. p. 455.

sharply defined from all others, and its members belong exclusively to the warmer seas. The extreme forms of the *Eucheilosporum* and of the *Alatocladia* show indeed some differences with regard to their habit and the external appearance. But I consider the differences not to be of sufficient tenor to justify their separation into different genera. In the *Alatocladia* the position of the conceptacles is rather indeterminate, so that we can not delineate a sharp boundary to separate it from the *Eucheilosporum*.

The *Serraticardia* has the external form closely resembling that of the *Arthrocardia*. By the position of the conceptacles and the pinnation of the branchlets, these two sections may easily be distinguished one from another. Only two species are assigned to the former section. They have two sorts of conceptacles, which may occur in an individual or in one branch at the same time. One is imbedded at the top of the branchlet, or articulated lobe, as it were. Another is situated upon the surface of articulus. The former character suggests *Corallina* and the latter, no doubt, is the peculiarity found in the members of the *Alatocladia*.

Sect. I. EUCHEILOSPORUM YENDO. Enumer. Cor. p. 193.

Cheilosporum elegans ARESCH. in J. AG. Spec. Alg. II. p. 546.

= *Amphiroa elegans* HOOK. et HARV. Ner. Austr. p. 101. Pl. XXXVIII.

C. sagittatum ARESCH. in J. AG. Spec. Alg. II. p. 545.

= *Corallina sagittata* LAMX. Freycin. Voy. p. 625. t. 95. fig. 11-12.

= *Amp. sagittata* DCNE. Mémoir. p. 113.

C. jungermannioides RUPR. in J. AG. Spec. Alg. II. p. 546.

C. spectabile HARV. Friendly Isl. Alg. no. 31.

C. cultratum ARESCH. in J. AG. Spec. Alg. II. p. 545.

= *Amp. cultrata* HARV. Ner. Austr. p. 102. Pl. XXXIX.

β debilis †

= *Amp. cultrata* β *debilis* KÜTZ. Tab. Phyc. VIII. p. 27. Tab. 54. fig. k. l.

= *Amp. cultrata* γ *globulifera* KÜTZ. l. c. Tab. 55. fig. 1.

δ pectinata †

= *Amp. cultrata δ pectinata* KÜTZ. l. c. Tab. 55. fig. 2.

f. multifida †

= *Amp. multifida* KÜTZ. l. c. Tab. 56. fig. 1.

SPECIES DOUBTFUL.

Amphiroa acutiloba DCNE. Mémoir. p. 113.

Amp. Lamourouxiana DCNE. l. c. p. 113.

= *Corallina Lamourouxiana* LEACH. in Herb. LAMX. (sec. DCNE. l. c.)

Amp. fastigiata DCNE. Mémoir. p. 113.

Amp. heterocladia KÜTZ. Tab. Phyc. VIII. p. 27. Tab. 55. fig. 1.

Cheilosporum pulchrum HARV. (sec. SONDER. in Fragmenta. p. 20.)

The doubtful species above mentioned are too briefly defined to make it safe to count them as independent species. *Amp. heterocladia* KÜTZ. is referrible to either *Cheil. Stangeri* or *Cheil. flabellatum*. The linear or cylindrical articuli in some part of the frond are often found in an abnormal form of this section, and their presence is never a constant character. *Amp. cultrata* HARV. *γ globulifera* KÜTZ. is the name given to a plant having the conceptacles of *Choreonema*.

Except these questionable plants, most of the members are clearly defined and acknowledged by many eminent systematists.

Sect. II. ALATOCLADIA †

= *Arthrocardia* DCNE. p. p. Mémoir. p. 112.

= *Arthrocardia* YENDO. Enumer. Coral. p. 192.

= *Arthrocardia* ARESCH. p. p. in J. AG. Spec. Alg. II. p. 548.

Cheilosporum californicum YENDO. Cor. ver. Port Renfrew. p. 715. Pl. LIV. fig. 2; Pl. LVI. fig. 3.

= *Amphiroa californica* DCNE. Mémoir. p. 112.

= *Amp. tuberculosa f. californica* SETCH. et GARD. Alg. N. W. Amer. p. 361.

C. frondescens YENDO. Cor. ver. Port Renfrew. p. 715.

f. typica YENDO. l. c. p. 715. Pl. LII. fig. 1.; Pl. LVI. fig. 4, 5 and 8.

- = *Corallina frondescens* POST. et RUPR. Illustr. p. 20. t. 40. fig. 103.
- = *Arthrocardia?* *frondescens* ARESCH. in J. AG. Spec. Alg. II. p. 549.
- = *Amphiroa Hookeri* HARV. (sec. HARV. Ner. Bor. Amer. p. 86).
- = *Amp. tuberculosa* f. *frondescens* SETCH. et GARD. Alg. N. W. Amer. p. 362.
- f. maxima** YENDO. Cor. ver. Port Renfrew. p. 716.
- f. intermedia** YENDO. l. c.
- f. polymorpha** YENDO. l. c.
- C. filiculum** †
 - = *Cheilosporum palmatum* β *filiculum* YENDO. Enumer. Cor. p. 192.
 - = *Arthrocardia palmata*, et β ARESCH. in J. AG. Spec. Alg. II. p. 550.
 - = *Corallina filicula* LAMK. Mem. Mus. II. p. 237.
- var. planiusculum** †
 - = *Cheilosporum planiusculum* YENDO. Cor. ver. Port Renfrew. p. 717. Pl. LIII. fig. 1-3: Pl. LVI. fig. 9-10.
 - = *Corallina planiuscula*, et ff. KÜTZ. Tab. Phyc. VIII. p. 31. Tab. 63. fig. 3.
 - = *Amp. tuberculosa* f. *planiuscula* SETCH. et GARD. Alg. N. W. Amer. p. 363.
- C. Stangeri** ARESCH. in J. AG. Spec. Alg. II. p. 544.
 - = *Amphiroa Stangeri* HARV. Ner. Austr. p. 101. Pl. XXXIX.
- C. flabellatum** ARESCH. in J. AG. Spec. Alg. II. p. 544.
 - = *Amp. flabellata* HARV. Ner. Austr. p. 101. Pl. XXXIX.
- C. Darwini** †
 - = *Amp. Darwini* HARV. Ner. Austr. p. 100.
 - = *Arthrocardia Darwini* W. v. B. Coral. Sib. Exp. p. 106.
- C. anceps** YENDO. Cor. ver. Jap. p. 18. Pl. II. fig. 6-8: Pl. VI. fig. 2.
 - = *Corallina anceps* KÜTZ. Phyc. Gen. p. 388.
- var. modesta** YENDO. Cor. ver. Jap. p. 19. Pl. II. fig. 9: Pl. VI. fig. 3.
- C. Orbignianum** †
 - = *Amp. Orbigniana* DUNE. Mémoire. p. 112.
- C. latissimum** YENDO. Cor. ver. Jap. p. 21. Pl. II. fig. 16-17: Pl. VI. fig. 7.
- C. yessoense** YENDO. l. c. p. 19. Pl. II. fig. 12-13: Pl. VI. fig. 5.
 - f. angusta** YENDO. l. c. p. 19. Pl. II. fig. 14-15: Pl. VI. fig. 6.
- C. tuberculosum** †
 - = *Corallina tuberculosa* POST. et RUPR. Illustr. p. 20 t. 40. fig. 100.
 - = *Amp. tuberculosa* ENDL. Mantissa. Suppl. III. p. 49.

- = *Arthrocardia* ? *tuberculosa* DCNE. Mém. p. 110.
- = *Arthro. tuberculosa* W. v. B. Coral. Sib. Exp. p. 110.
- = *Amp. tuberculosa* f. *typica* SETCH. et GARD. Alg. N. W. Amer. p. 361.
- = *Amp. epiphlegmoides* J. AG. in HARV. Alg. from N. W. Amer. p. 169.
- = *Arthro. epiphlegmoides* W. v. B. Coral. Sib. Exp. p. 106.

SPECIES DOUBTFUL.

- Amphiroa firma* KÜTZ. Spec. p. 704.
- Corallina Filicula* KÜTZ. Tab. Phyc. VIII. p. 30. Tab. 61. fig. 1.
- Cor. carinata* KÜTZ. Tab. Phyc. VIII. p. 30. Tab. 61. fig. 2.
- Amp. chilensis* DCNE. Mém. p. 113.
- Amp. vertebralis* DCNE. l. c. p. 112.
- = *Arthrocardia vertebralis* W. v. B. Coral. Sib. Exp. p. 106.
- Amp. prolifera* DCNE. Mém. p. 113.
- = *Cor. prolifera* LAMX. Histoir. p. 291. Tab. 10. fig. 5.

The section *Arthrocardia*, as before stated, was first distinguished by DECAISNE¹⁾ as the second division of *Amphiroa*; and comprised many species of the present section and a few of *Arthrocardia* in the sense in which the present writer uses that term. It was elevated to a genus by ARESCHOU with modification however in the sense, on account of the characteristic position of conceptacles. SCHMITZ and HAUPTFLEISCH²⁾ combined it with the *Eucheilosporum*, including both under the genus *Cheilosporum*. SETCHELL and GARDNER³⁾ in their joint work remarked that they could not discover why the present writer⁴⁾ referred some of the Canadian forms, such as *Cheilosporum frondescens*, *Cheil. filiculum* f. *planiusculum* (= *Cheil. planiusculum*), etc., to the genus *Cheilosporum*. To remove their doubt it will be

1) Mém. p. 112.

2) ENGLER. u. PRANTL: Pflanzenfamilien. p. 543.

3) Notes on N. W. Amer. Alg. p. 369.

4) Cor. ver. of Port Renfrew. p. 715.

sufficient simply to remark that *Corallina frondescens* Post. et Rupr. was referred to *Arthrocardia* by ARESCHOUG,¹⁾ though with some doubt; and that *Arthrocardia* was reduced to *Cheilosporum* by SCHMITZ.²⁾ But I referred the Canadian algæ to *Cheilosporum* not merely because I was strengthened by ARESCHOUG's opinion. Some further remarks will be added below.

The principal difference between this genus and *Amphiroa* lies in the fact that in the former the mother cells of the propagating cells originate in the medullary portion of the fronds, while in *Amphiroa* they are in the cortical. The scars of the dropped conceptacles prove the difference. This is easily recognized by the practiced eye. But to get the exact view, one microtome section of the fertile articuli through a conceptacle is sufficient. This is quite clear if the reader refers to the figures which I have repeatedly delineated in my former papers.³⁾

The distinguishing point between the typical forms of the *Eucheilosporum* and the *Alatocladia* lies in the position of the conceptacles. In the former the normal position of the conceptacles is the upper margin of the sagittate articuli; as a rule, only one conceptacle is found in a wing of an articulus. In the latter, one or more conceptacles are on the flat surface or the outer margins of the wings of the reniform or sagittate articuli, Hence the fertile branches of the *Alatocladia* have articuli with a pair or more of conceptacles. Cf. Pl. LVI. figg. 5, 7 and 13 in "Cor. ver. Port Renfrew:" and Pl. II. figg. 12, 14 and 16 in "Cor. ver Japon."

1) J. Ag.: Spec. Alg. II. p. 549.

2) Syst. Uebersicht. p. 455.

3) Coral. ver. Japon. Pl. II. figg. 6, 8, 14 and 16: Cor. ver. Port. Renfrew. Pl. LVI. figg. 3 and 8.

There are, however, numerous species which have the normal conceptacles at the external margins of the articuli, displaying, in a manner, the link between the *Eucheilosporum* and the *Alatocladia*. *Cheilosporum yessoense* and *Cheil. latissimum* are the best examples. Cf. Pl. II. figg. 12 and 16, "Cor. ver. Japon." We should find some difficulty in reckoning the former species under the *Alatocladia*, had not some conceptacles been found on the flat surface of the articuli, before examining a microtome section of a conceptacle.

The sharp boundary between the two sections above mentioned is by no means easily delineated. In practice, however, we can distinguish them with the utmost safety by the size of the frond, the shape of the articuli and the locality of the plants. Almost all of the *Eucheilosporum* are inhabitants of warmer climates: the articuli are sagittate with sharp pointed wings; and the height of the frond hardly exceeds a few inches. These characters are of-course arbitrary and may not be clearly ascertained in some intermediate forms. Still they are often useful in determining a sterile plant.

SETCHELL and GARDNER,¹⁾ after their long study, hold the opinion that *Cheil. frondescens*, etc., must be united to the formæ of *Amp. tuberculosa* ENDL. The present writer wishes to be allowed to add a few words concerning their view.

Cheilosporum (*Amphiroa*) *tuberculosum* is a peculiar plant. It has the characters of both the *Arthrocardia* and the *Alatocladia* in the external as well as in the internal points. DECAISNE²⁾ has already noticed that it belongs to the section *Arthrocardia*

1) Alg. N. W. Am. p. 360.

2) Mémoir. p. 110.

DCNE., and ARESCHOUG,¹⁾ without hesitation, assigned the species to the genus *Amphiroa*. I²⁾ have enumerated it under the genus *Amphiroa* but with much uncertainty. The fronds have both sorts of articuli, the homogeneous cylindrical ones and the compressed reniform. These forms occur in different branches separately but frequently in the same branch. Cf. Pl. LI. "Cor. ver. Port Renfrew." The conceptacles are always found upon the flattened articuli, in the same manner as is characteristic of the *Alatocladia*. This character suggests *Cheilosporum* much more than it does *Amphiroa*. The microtomic section of the fertile articuli shows some conceptacles originate deep in the medulla and some apparently in the cortex. This fact greatly perplexed me in distinguishing the generic position of the plant, but I provisionally followed the opinion of ENDLICHER,³⁾ and reckoned it under *Amphiroa*. The reader may notice that the diagrammatic figure⁴⁾ of the cross section of the articulus with four conceptacles is the only one figure in my former papers which does not give the boundaries in the fine dotted line between the medulla and the cortex. The origin of the spores in this species, as above mentioned, is uncertain in some degree. But the presence of the conceptacles exclusively on the compressed articuli is a character which suggests disposition as above. It might well be considered as a transitional form linking the *Alatocladia* to the *Arthrocardia*.

The reduction of a species to a forma or variety of a distinct species depends upon the view of the author. A character may be taken as specific or as formal. No one can judge which should

1) J. Ag. : Spec. Alg. II. p. 538.

2) Cor. ver. Port Renfrew. p. 714.

3) Mantissa, § Suppl. III. p. 49.

4) Cor. ver. Port Renfrew. Pl. LVI. fig. 1.

be absolutely legitimate. But the reduction of the Canadian species to the formæ of *Cheilosporum tuberculosum*, as has been done by SETCHELL and GARDNER, is by no means acceptable. The latter species undoubtedly has variable characters, apparently fluctuating from one to the other: while the others have, not without reason, been described by many systematists for a long time as distinct species.

In my former paper on *Corallinæ* of Port Renfrew I had doubt regarding *Amp. epiphlegmoides* J. AG. But as I had not been fortunate enough to see the original specimen, I placed it provisionally under *Cheil. (Amphiroa) tuberculosum*. MADAM WEBER,¹⁾ after examining the specimen in the British Museum, thinks it very likely that it is only a form of latter species, as I had supposed. Strengthened by her remark, I here reduce the species in question as synonymous with *Cheil. tuberculosum*.

Corallina palmata ELLIS et SOL. was transfered to *Arthrocardia* by ARESCHOUG. But I had no less doubt regarding his opinion in doing so when I compared the definition of *Arthrocardia palmata* ARESCH. with the description of *Corallina palmata* ELLIS et SOL. given by various authors. Lately I was fortunate enough through the kindness of MADAM WEBER VAN BOSSE to study the specimens, labelled "*Arthrocardia palmata* ARESCH." and "*Corallina palmata* ELLIS et SOL.," which were kept in the Herbarium of SURINGAR. After careful examination of the specimens, and referring to almost all of the literature concerning both species, I have come to the conclusion that the species *Arthrocardia palmata* ARESCH. is quite different from *Corallina palmata* ELLIS et SOL. SURINGAR's specimen of *Arth. palmata* is sterile. But it accords very well with the description of *Arth.*

1) Coral. Siboga Exp. p. 106.

palmata f. β of ARESCHOUG. It stands closely to *Cheil. planiusculum* YENDO, and the latter may well be taken as its variety. The difference lies in the shape of articuli; the axial articuli of the former having much more projected lobes, and those in the latter being nearly triangular. Hence the specific name *Corallina Filicula* should be reserved by priority. The illustration of *Cor. Filicula* delineated by KÜRZING in his Tab. Phyc. VIII. Taf. 60. fig. 1. seems to represent a different species.

Not a few of the present members have been unsatisfactorily defined. Some of DECAISNE'S species which he described from American plants should probably be reduced as synonymous with others, or some described by other authors afterwards may be identical with his. DECAISNE'S original definitions are often incomplete and good for more than two distinct forms. Actual examination of the authentic specimens is necessary to the solution of this problem.

Sect. III. SERRATICARDIA YENDO. Enumer. Cor. Alg. p. 193.

Cheilosporum maximum YENDO. Cor. ver. Jap. p. 21. Pl. II. fig. 18-19 : Pl. VI. fig. 9.

C. McMillani YENDO. Cor. ver. Port Renfrew. p. 718. Pl. LII. fig. 4-5 : Pl. LVI. fig. 11-14.

SPECIES DOUBTFUL.

Corallina officinalis L. f. *robusta* SETCH. et GARD. (nec Kjellm.) Alg. N. W. Amer. p. 365.

The present section is characterized by the peculiar position of the conceptacles. Those on the hexagonal articuli, mostly in pairs, show the relationship to the *Alatocladia*; those imbedded in the apices of the pinnated ramuli suggest a transition to *Corallina*. It differs from the latter genus by having the compressed con-

ceptacles as in the *Eucheilosporum*. The conceptaculiferous pinnules may be considered as the apices of the sagittate articuli enormously prolonged and finally jointed. I have formerly mentioned such a circumstance in a frond of the *Eucheilosporum*.¹⁾

SETCHELL and GARDNER²⁾ have doubted my species and think them the robust forms of *Corallina*. They hesitatingly referred *Cheil. McMillani* to a coarse form of Californian *Corallina*: and further stated that they could not find any conceptacles on the surface of the articuli of their *Corallina* except some which seemed that of *Choreonema*. A single glance at a section of the conceptacles under the microscope will determine whether it belongs to the plant proper or to the parasite. Pl. II. fig. 19. of "Cor. ver. Japon" shows the cross section of the conceptacles of *Cheil. maximum*. No one can confuse the comparatively conspicuous conceptacles of *Corallinæ* with the small sized ones of *Choreonema*. I am quite convinced by ARESCHOUG when he writes in J. Ag's. Spec. Alg. II. p. 564 as follows: "Quæ sub hoc nomine (*Corallina officinali* L.) inde (e Capite bonæ spei) accepimus, sunt cum *Arthrocardiæ palmatæ*, tum *Arthrocardiæ corymbosæ* formæ juniores, quæ pro *Corallina officinali* ab incauto facile haberi possunt."

Gen. VI. CORALLINA LAMX.

= *Titanephillum* NARDO. (sec. ENDLICHER).

Although we can not find a detailed account, it is not hard to understand that it was on the following ground that SOLMS-

1) Cor. ver. Japon. p. 12. Cf. also Kütz.: Tab. Phyc. VIII. Tab. 54.

2) Alg. N. W. Amer. p. 365.

LAUBACH¹⁾ united *Jania* LAMX. with *Corallina* LAMX. He noticed the pinnated ramuli in *Jania corniculata* and referred it to a variety of *Jania rubens*. He also, at the same time, remarked that the pinnation is a character which has hitherto played the important part in separating *Corallina* from *Jania*, which was defined as branching dichotomously.

I can not acquiesce in the opinion that the pinnation of *Jania corniculata* LAMX. is identical in its nature with that of *Corallina*. The members of *Jania* seem to have the ability of issuing pinnate or subpinnate ramuli at the lower portion of a frond. *Jania micrarthrodia* f. *antennina* (Kütz.) is the actual example, besides the above mentioned species. Cf. Tab. Phyc. VIII. Taf. 84. fig. 1. Yet all the members of *Jania* are sharply defined as having the dichotomous branches at the apical portions of the fronds. The conceptacles of *Jania*, even in the pinnated fronds, are always found at the dichotomous points of the upper ramuli, or at the apical points. In *Corallina*, as a rule, they are at the ends of pinnae or the pinnules. I cannot discover any necessity of uniting both genera simply for the reason that there is a species in a genus which shows, in a manner, a similar character to one found in the other genus; and more so, if this common character is a vegetative one. This circumstance suggests to us that both genera are related to one another and not that they must be united into one.

I held this opinion long ago and mentioned *Jania* as a subgenus in the list of Japanese Corallinaceæ.²⁾ But I found it better to restore the genus in LAMOUROUX's sense. The regularity of the dichotomous ramification, which is rarely disturbed, seems

1) *Corallina*. p. 6. foot note.

2) Enumeration of Cor. Alg. p. 193.

to have special signification in the phylogeny. The other characters limited to the group indicate generic rank rather than subgeneric.

DECAISNE and his followers ascribe the establishment of the genus *Corallina* to TOURNEFORT, while ARESCHOUG chooses LAMOUROUX as its founder. The latter author remarks that the genus *Corallina* in TOURNEFORT's sense comprised *Algæ* and *Zoophyte* together. I am inclined to think that the recent definition of *Corallina* is largely drawn from the elaborate work of LAMOUROUX.

Sect. I. OFFICINALES †

Corallina officinalis L. f. **typica** KJELLM. Alg. Arct. p. 86.

= *Corallina officinalis*, a. ARESCH. in J. AG. Spec. Alg. II. p. 562.

= *Cor. officinalis vulgaris* KÜTZ. Tab. Phyc. VIII. p. 32. Tab. 66. fig. 2.

= *Cor. officinalis* L. Fauna Suec. n. 2234. (sec. ARESCH. l. c.).

= *Cor. articulata* ELLIS. Coral. p. 60. t. 24. fig. a. A.

= *Cor. nana* ZANARD. Coral. p. 20. (sec. ZANARD. Iconogr.)

= *Cor. laxa* LAMK. Mem. Mus. II. p. 231.

= *Cor. spathulifera* KÜTZ. Spec. p. 709.

= *Cor. longicaulis* LAMK. Mem. Mus. II. p. 232.

= *Cor. officinalis* γ YENDO. Cor. ver. Jap. p. 29. Pl. III. fig. 13 : Pl. VII. fig. 12.

= *Cor. officinalis f. typica* SETCH. et GARD. Alg. N. W. Amer. p. 364.

f. paltonophora KÜTZ. Tab. Phyc. VIII. p. 33. Tab. 68. fig. 2.

f. flexilis, KJELLM. Alg. Arct. p. 86.

f. robusta, KJELLM. l. c.

f. mediterranea KÜTZ. Tab. Phyc. VIII. p. 32. Tab. 66. fig. 3.

f. Farnoesis KÜTZ. l. c. p. 33. Tab. 68. fig. 1.

b. ARESCH. in J. AG. Spec. Alg. II. p. 563.

= *Cor. angelica* ELLIS et SOL. Coral. p. 63. t. 24. fig. 3.

= *Cor. elongata* ELLIS et SOL. l. c. p. 119.

c. ARESCH. in J. AG. Spec. Alg. II. p. 563.

= *Cor. nodularia* PALL. Elench. Zooph. p. 421.

- = *Cor. loricata* ELLIS et SOL. Coral. p. 17.
- α YENDO. Cor. ver. Jap. p. 28. Pl. III. fig. 11: Pl. VII fig. 10.
- ? = *Corallina officinalis fastigiata* KÜTZ. Tab. Phyc. VIII. p. 32. Taf. 67. fig. 1.
- β YENDO. Cor. ver. Jap. p. 28. Pl. III. fig. 12: Pl. VII. fig. 11.
- ? = *Cor. officinalis elator* KÜTZ. Tab. Phyc. VIII. p. 32. Taf. 67. fig. 2.
- β **mediterranea** HAUCK. Meeresalgen. p. 281.
- = *Cor. mediterranea* ARESCH. in J. Ag. Spec. Alg. II. p. 568.
- = *Cor. granifera* KÜTZ. (nec ELLIS et SOL., nec SOND.) Spec. p. 709.
- = *Cor. densa* KÜTZ. Spec. p. 705.
- var. chilensis** KÜTZ. Tab. Phyc. VIII. p. 32. Taf. 66. fig. 1.
- = *Cor. chilensis* DCNE. in Herb. Paris. (sec. HARV. Ner. Austr. p. 103).
- = *Cor. officinalis* δ YENDO. Cor. v. Jap. Pl. VII. fig. 13.
- var. profunda** FARL. Mar. Alg. New Eng. p. 179.
- Corallina squamata** ELLIS et SOL. Coral. p. 117.
- = *Cor. cupressina* LAMK. Mem. Mus. II. p. 233.
- = *Cor. abietina* LAMK. l. c.
- = *Amphiroa heterarthra* TREV. Flora. no. 27. p. 416. (sec. TREV.).
- Cor. virgata** ZANARD. KÜTZ: Phyc. Gen. p. 397.
- = *Cor. attenuata* KÜTZ. Tab. VIII. p. 37. Tab. 77. fig. 1.
- = *Cor. granifera* ELLIS et SOL. Coral. p. 120. t. 21. fig. c. C.
- = *Cor. Bertiana* DE NOT. (sec. PRED. Primo Contr. p. 80).
- = *Cor. gibbosa* KÜTZ. Tab. Phyc. VIII. p. 39. Tab. 82. fig. 2.
- Cor. ceratoides** KÜTZ. Tab. Phyc. VIII. p. 36. Tab. 75. fig. 2.
- Cor. elegans** LENORM. in J. Ag. Spec. Alg. II. p. 570.
- Cor. pectinata** LAMK. Mem Mus. II. p. 233.
- Cor. pilulifera** POST. et RUPR. Illustr. p. 20. t. 40. fig. 101.
- = *Cor. officinalis* L. f. *pilulifera* SETCH. et GARD. Alg. N. W. Amer. p. 366.
- f. flabellata** RUPR. Tange. p. 344.
- f. filiformis** RUPR. l. c.
- f. Sororia** RUPR. l. c.
- f. intermedia** YENDO. Cor. ver. Jap. p. 30. Pl. III. fig. 16: Pl. VII. fig. 16.
- f. arbuscula** †
- = *Cor. arbuscula* POST. et RUPR. Illustr. p. 20. Tab. 40. fig. 102.
- Cor. capensis** LEACH. in DECAISNE: Mémoir. p. 107.
- = *Arthrocardia capensis* ARESCH. in J. Ag. Spec. Alg. II. p. 552.

- Cor. sessilis** YENDO. Cor. ver. Jap. p. 32. Pl. III. fig. 18 : Pl. VII. fig. 18.
Cor. Berterii MONT. Flor. Chil. (sec. HARV.: Ner. Austr. p. 103),
Cor. kaifuensis YENDO. Cor. ver. Jap. p. 33. Pl. III. fig. 19 : Pl. VII. fig. 19.
Cor. confusa YENDO. l. c. p. 34. Pl. III. fig. 20 : Pl. VII. fig. 20.
Cor. armata HOOK. et HARV. Ner. Austr. p. 103. Pl. XI.
Cor. vancouveriensis YENDO. Cor. ver. Port Renfrew. p. 719. Pl. LIV. fig. 3 : Pl. LVI. fig. 1-2 : Pl. LVI. fig. 16-17.
 = *Cor. officinalis f. multiramosa* SETCH. et GARD. Alg. N. W. Amer. p. 366.
f. typica YENDO. Cor. ver. Port Renfrew. p. 719. Pl. LIV. fig. 3 : Pl. LVI. fig. 16.
 = *Cor. officinalis f. multiramosa subf. laxa* SETCH. et GARD. Alg. N. W. Amer. p. 367.
f. densa YENDO. Cor. ver. Port Renfrew. p. 719. Pl. LV. fig. 1 : Pl. LVI. fig. 17.
 = *Cor. officinalis f. multiramosa subf. densa* SETCH. et GARD. Alg. N. W. Amer. p. 367.
Cor. aculeata YENDO. Cor. ver. Port Renfrew. p. 720. Pl. LV. fig. 3 : Pl. LVI. fig. 18-19.
 = *Cor. officinalis f. aculeata* SETCH. et GARD. Alg. N. W. Amer. p. 367.

SPECIES DOUBTFUL.

- Amphiroa variabilis* HARV. Ner. Austr. p. 98.
 = *Arthrocardia variabilis* W. v. B. Coral. Sib. Sxp. p. 106.
Corallina bifurca KÜTZ. Tab. Phyc. VIII. p. 41. Tab. 86. fig. 3.
Cor. lobata LAMX. Histor. p. 285.
Cor. cubensis KÜTZ. Tab. Phyc. VIII. p. 37. Tab. 77. fig. 2.
 = *Jania cubensis* MONT. (sec. KÜTZ.: Spec. p. 708).
Cor. Deshaysii MONT. fide HARV. Ner. Austr. p. 103.
Cor. muscoides KÜTZ. Tab. Phyc. VIII. p. 42. Tab. 84. fig. 5
Cor. polychotoma LAMX. Histor. p. 285.
Cor. simplex LAMX. l. c. p. 290. t. 10. fig. 4.
Cor. pinnata ELLIS et SOL. Coral. p. 117.
Cor. racemosa KÜTZ. Tab. Phyc. VIII. p. 41. Tab. 85. fig. 1.
Cor. hemisphaerica FOSL. Nye Havsalg. Tromø Mus. Aarsh. X.
Cor. Calvadosii LAMX. Histor. p. 290.
 = *Cor. officinalis f. d.* ARESCH. in J. Ag. Spec. Alg. II. p. 563.
Cor. palmata ELLIS et SOL. Coral. p. 118. Tab. 21. fig. a. A.
 = *Cor. flabellata* KÜTZ. Tab. Phyc. VIII. Tab. 60. fig. 2.

The representative member of the present section, *Corallina officinalis* L., is universally distributed. The plant undergoes much morphological change according to the condition of the place where it grows. Numerous formæ have been described and many forms were mentioned as distinct species or varieties. The best authorities, however, agree in the opinion that many of the formæ are local variations and not worth mentioning separately. If a widely differing form be reduced to the variety or forma, because of some similarity to *Corallina officinalis* L., only a few species among those listed above may retain their specific position. There is no doubt, as I formerly mentioned, that the forms hitherto mentioned as *Corallina officinalis* may have been confounded with various distinct plants; or, on the contrary, some of the plants described as independent species may be reduced to formal or often to synonymous position. At present, however, the revision of the specimens of *Corallina officinalis*, reported from innumerable localities, is beyond my power. I must confine myself here to mentioning the formæ hitherto described with more or less exact definitions; and at the same time trying to make the nearest possible references thereof.

SETCHELL and GARDNER¹⁾ combined *Coriallina pilulifera* POST. et RUPR., *Cor. vancouveriensis* mihi, and *Cor. aculeata* mihi, as the formæ of *Cor. officinalis* L., and mentioned a number of sub-formæ under them. It is a matter of personal preference whether the plants with such affinity should be taken as formæ or as distinct species. The plants, however, which have characters more or less constant and easily distinguishable from the typical forms of *Cor. officinalis* L. may be considered as distinct species.

1) Alg. N. W. Amer. p. 366.

Corallina sessilis is a peculiar plant. It was first described by the present writer in "Cor. ver. Japon." p. 32. Lately I also found it among a collection of *Corallina* from Australia, sent by DR. OKAMURA for determination.¹⁾ The position and the form of the conceptacles show the characters of *Corallina*; and at the same time are referrible in some respects to both the *Serraticardia* and the *Alatocladia*. Cf. "Cor. ver. Japon." l. c. Judging from the description given by HARVEY in Ner. Austr. l. c., *Amphiroa variabilis* HARV., which was described from a sterile specimen, is probably related to this species.

ARESCHOUG doubted the generic position of *Cor. capensis* LEACH., but he provisionally included it under *Arthrocardia* ARESCH. He did not know the propagating organ of the species. There are two fertile specimens of "*Arthrocardia capensis* ARESCH." in SURINGAR's Herbarium, collected at Cape Agulhas, South Africa. They differ slightly in minor points but evidently accord with the description given by ARESCHOUG in J. Ag.'s Spec. Alg. II. p. 552, and one of them especially with *f. β* of ARESCHOUG. The conceptacles have a peculiar character resembling those of *Corallina sessilis* in general. As there has nothing been reported concerning the matter, it will not be superfluous to give some points in detail.

The articuli in the middle and upper portions are cuneate, more or less compressed above. Each upper corner of an articulus is mostly extended to a short spinous process. Very often we find one more process at the external side of the former situated very close and parallel. Both are never jointed, and are alike one to another. They elongate further, keeping their relative

1) Bot. Mag. Tokyo. Vol. XVIII. p. 92.

positions as before, but the inner one becoming gradually thicker and thicker, till finally it results in a pyriform, short-stiped conceptacle. The external process is now found at the lateral margin of the conceptacle, fused to the wall of the latter. The apex of the former is often found much more pronounced than the terminal end of the conceptacle, or, not infrequently, it takes place just upon the latter and thus the conceptacle seems to have apiculated.

The apparent difficulty in reckoning *Cor. sessilis* and *Cor. capensis* in the genus *Corallina* lies in the point that the conceptacles are not jointed. This character may suggest an extreme form of *Alatocladia* in some way. We must, however, remember that there are many conceptacles found in the *Officinales* without any joint to separate them from the axial articuli. Cf. "Cor. ver. Port Renfrew." Pl. LVI. fig. 16. I believe it will be safest to group these species under the present section, as I could not discover any conceptacle upon the surface of the hexagonal articuli of the axial stems.

Corallina palmata ELLIS et SOL. is a doubtful plant, as has been stated before (p. 26). GRUNOW mentions *Arthrocardia palmata* ARESCH. in the list of plants collected during the Novara Expedition (p. 79): and remark that the plant is similar to *Cor. flabellata* KÜTZ. illustrated in Tab. Phyc. VIII. Tab. 60. The specimen bearing the name of "*Corallina palmata* ELLIS et SOL.," kept in SURINGAR'S Herbarium, accords very well with the description of *Cor. palmata* ELLIS et SOL. and at the same time with the figures of *Cor. flabellata* KÜTZ. l. c. It is far from doubtful that this species should be better placed near *Amp. corymbosa* under the section *Arthrocardia*.

Most of the other doubtful species in the above list are

unsatisfactorily described, or referred to sterile specimens. *Cor. hemisphærica* FOSL. seems an unfixed local form of *Cor. officinalis* L.

Sect. II. HALIPTYLON DCNE. (Mut. strict.) Mémoir. p. 111.

Corallina Cuvieri LAMX. *a Cuvieri* ARESCH. in J. AG. Spec. Alg. II. p. 572.

= *Corallina Cuvieri* LAMX. Expos. Method. p. 24. t. 69. fig. 13-14.

= *Jania Cuvieri* DCNE. Mémoir. p. 111.

= *Jania granifera* SOND. Plant. Preiss. II. p. 187.

? = *Jania granifera* DCNE. Mémoir. p. 111.

β. crispata ARESCH. in J. AG. Spec. Alg. II. p. 572.

= *Cor. crispata* LAMX. Histoir. p. 289. t. 10. fig. 3.

= *Jania crispata* DCNE. Mémoir. p. 111.

= *Jania subulata* β *crispata* HARV. (sec. SOND. Plant. Müll. Cont. p. 522.)

δ. subulata ARESCH. emend. in J. AG. Spec. Alg. II. p. 572.

= *Cor. subulata* ELLIS et SOL. Coral. p. 120. t. 21. fig. B.

= *Jania subulata* SOND. Plant. Preiss. II. p. 186.

= *Cor. Cuvieri* β *subulata* KÜTZ. Tab. Phyc. VIII. p. 33. Tab. 70. fig. II.

f. denudata SOND. Plant. Müll. Cont. p. 521.

= *Cor. denudata* KÜTZ. Tab. Phyc. VIII. p. 34. Tab. 73.

f. densa †

= *Cor. gracilis* f. *densa* COLLINS. Phyc. Bor. Amer. no. 650.

var. calliptera GRUN. Novara Exp. p. 78.

= *Cor. calliptera* KÜTZ. Spec. p. 705.

= *Cor. gracilis* COLLINS, HOLD. et SETCH. Phyc. Bor. Amer. no. 399.

Cor. rosea LAMX. Mém. Mus. 1. p. 235.

= *Jania rosea* DCNE. Mémoir. p. 111.

Cor. pilifera LAMX. Histoir. p. 290.

Cor. trichocarpa KÜTZ. Tab. Phyc. VIII. p. 35. Tab. 74. fig. 1.

Cor. clavigera KÜTZ. Tab. Phyc. VIII. p. 36. Tab. 75. fig. 1.

Cor. pistillaris ARESCH. J. AG. Spec. II. 574.

= *Jania pistillaris* MONT. Pôle Sud. Bot. p. 147.

Cor. Hombronii KÜTZ. Spec. p. 708.

= *Jania Hombronii* MONT. Pôle Sud. Bot. p. 146.

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Corallina gracilis LAMX. *Histoir.* p. 288. t. 10. fig. 1. a. B.

= *Jania gracilis* MONT. *Pôle Sud. Bot.* p. 147.

Jania elegans DCNE. *Mémoire.* p. 111.

Cor. Turneri LAMX. *Histoir.* p. 289. t. 10. f. 2. a. B.

= *Cor. Cuvieri* γ *Turneri* KÜTZ. *Tab. Phyc.* VIII. p. 34. Tab. 70. fig. 2. h.

Cor. paniculata LAMX. *Freye. Voy.* p. 626.

= *Jania paniculata* DCNE. *Mémoire.* p. 111.

Cor. plumifera KÜTZ. *Spec.* p. 705.

Cor. rosea LAMX. β *crispa* KÜTZ. *Spec.* p. 708.

This division is characterized by the dense ramuli aggregated on both sides of the main branches. Morphologically speaking, the segments corresponding to the pinnæ as well as to the pinules of the *Officinales* are stunted in the present group, forming a sort of "kurztrieb." The simpler form suggests close affinity with the preceding section and there can be no sharp line drawn between the two. *Corallina Cuvieri* var. *calliptera*, *Cor. rosea*, etc., of this section are closely related to *Cor. Berterii* of the preceding section. Some vexatious and erroneous references, as a consequence, have been made in the genus. For example, *Jania granifera* SOND. was taken by ARESCHOUG¹⁾ as synonymous with *Cor. Cuvieri* LAMX.; KÜTZING²⁾ transferred the former to the genus *Corallina* keeping the original specific name: finally *Corallina granifera* KÜTZ. was referred by HAUCK³⁾ to *Cor. officinalis* L. Consequently, if these references have all been correctly made, *Cor. Cuvieri* LAMX. must be united with *Cor. officinalis* L., or at least there must be a close similarity between both species, which can not be readily admitted.

1) J. Ag. Spec. Alg. II. p. 572.

2) Spec. Alg. p. 708.

3) Meeresalg. p. 281.

DECAISNE assigned some of the members of the present section to the genus *Jania*. LAMOUROUX's original definition of *Jania*, which was followed by many distinguished systematists, can by no means include the present section. ARESCHOUG wisely reckoned them under *Corallina* instead of *Jania*.

Corallina gracilis LAMX. has been held in doubt by ARESCHOUG.²⁾ This species has not been fully defined and is hardly referrible to other plants without authentic specimens. In Phyc. Bor.-Amer.³⁾ this name is assigned to one of the plants. The specimen is more applicable to *Cor. Cuvieri* var. *calliptera* GRUN. than the imperfectly described species of LAMOUROUX. COLLINS mentioned, in no. 650. of the same exsiccate, a plant bearing the name of *Corallina gracilis* LAMX. var. *densa* COLLINS. But the plant labelled no. 650 b. in the copy kept in my herbarium is quite distinct from the type species with regard to the characters of the articuli of the axial stems. It is related in several respects to a form of *Cor. Cuvieri*. It probably belongs to an undescribed species and must wait further study with a large stock of specimens. The specimen labelled 650. a. contains many fragments of distinct forms, all of which it is improper to refer to no. 650.

Almost all of the members of this section are inhabitants of the Australian seas.

Gen. VII. JANIA LAMX.

Jania adhærens LAMX. *Histoir.* p. 270.

= *Corallina adhærens* KÜTZ. *Spec.* p. 710.

J. decussato-dichotoma †

1) *Mémoire.* p. 111.

2) *J. Ag. Spec. Alg.* II. p. 572.

3) COLLINS, HOLDEN and SETCHELL. No. 399.

= *Cor. decussato-dichotoma* YENDO. Cor. v. Jap. p. 25. Pl. III. fig. 1-3: Pl. VII. fig. 3-4.

= *Cor. adherens* KÜTZ. p. p. Tab. Phyc. VIII. p. 40. t. 83.

J. micrarthrodia LAMX. *a tenuissima* ARESCH. in J. AG. Spec. Alg. II. p. 555.

= *Cor. tenuissima* KÜTZ. Tab. Phyc. VIII. p. 40. Tab. 84. fig. 3.

= *Jania tenuissima* SOND. Plant. Preiss. p. 39.

f. antennina †

= *J. micrarthrodia* β ARESCH. in J. AG. Spec. Alg. II. p. 555.

= *J. micrarthrodia* LAMX. Histoir. p. 271. t. 9. fig. 5. a. B.

= *J. antennina* KÜTZ. Phyc. Gen. p. 389.

= *Cor. antennina* KÜTZ. Tab. Phyc. VIII. p. 40. Tab. 84. fig. 1.

J. rubens LAMX. Histoir. p. 272.

= *Cor. rubens* L. Syst. Natur. ed. 12. Vol. I. p. 1304.

= *Cor. dichotoma* ELLIS et SOL. Coral. p. 65. t. 24. fig. f. F.

= *J. cristata* ENDL. Mantissa. Suppl. III. p. 49.

= *J. rubens* *C cristata* LAMX. Histoir. p. 272.

= *Cor. cristata* ELLIS. Coral. t. 27. n. 7.

= *Cor. rubens cristata* KÜTZ. Tab. Phyc. VIII. p. 38. Tab. 80. fig. 2.

E concatenata LAMX. Histoir. p. 273.

= *Cor. rubens* β *concatenata* KÜTZ. Tab. Phyc. VIII. p. 40. Tab. 84. fig. 4.

= *Cor. intermedia* KÜTZ. Tab. Phyc. VIII. p. 37. Tab. 79. fig. 1: p. 42. Tab. 86. fig. 4.

var. corniculata †

= *Cor. corniculata* L. Syst. Natur. ed. 12. Vol. I. p. 1305.

= *J. corniculata* LAMX. Histoir. p.

= *Cor. corniculata* ELLIS et SOL. Coral. p. 121. t. 24. fig. d. D.

= *Cor. alba* ELLIS. Coral. p. 65. t. 24. fig. d. D.

= *J. plumula* ZANARD. Coral. p. 21.

= *Cor. plumula* KÜTZ. Tab. Phyc. VIII. p. 41. Tab. 86. fig. 1.

= *Cor. rubens* var. *corniculata* HAUCK. Meersalg. p. 279.

J. longifurca ZANARD. Coral. p. 21.

= *Cor. longifurca* ZANARD. Iconogr. II. p. 63. Tab. 56.

J. capillacea, HARV. Ner. Bor. Amer. II. p. 84.

J. ungulata †

= *Cor. ungulata* YENDO. Cor. ver. Jap. p. 26. Pl. III. fig. 7-8: Pl. VII. fig. 8.

f. brevior †

= *Cor. ungulata* f. *brevior* YENDO. l. c. p. 27. Pl. III. fig. 9: Pl. VII. fig. 9.

- J. purpurata** BLAINV. in Kütz. Spec. Alg. p. 710.
 = *Cor. purpurata* LAMK. Mem. Mus. II. p. 237.
- J. crassa** LAMX. Expos. Method. p. 23. t. 69. f. 9-10.
 = *J. micrarthrodia* LAMX. d. ARESCH. J. Ag. Spec. Alg. II. p. 555.
 = *Cor. crassa* COLL. Phyc. Bor. Amer, no. 500.
- J. nipponica** †
 = *Cor. nipponica* YENDO. Cor. ver. Jap. p. 23. Pl. II. fig. 20 : Pl. VII. fig. 1.
- J. pacifica** ARESCH. in J. Ag. Spec. Alg. II. p. 556.
- J. fastigiata** HARV. Ner. Austr. p. 107.
- J. natalensis** HARV. l. c.
 = *Cor. natalensis* Kütz. Tab. Phyc. VIII. p. 38. Tab. 79. fig. 2.
- J. yenoshimensis** †
 = *Cor. yenoshimensis* YENDO. Cor. ver. Jap. p. 23. Pl. II. fig. 21-24 : Pl. VII. fig. 2.
- J. Novæ Zelandiæ** HARV. Fl. N. Z. II. p. 237. (sec. Hooker : Handbook. p. 2.)
- J. affinis** HARV. (sec. SONDER : Alg. Austr. p. 21.)
- J. spermaphros** Kütz. Spec. p. 708.
 = *J. rubens* var. *D. spermaphros* LAMX. Histoir. p. 272.
 = *J. rubens* var. *B. pyriferæ* LAMX. l. c.
 = *Cor. spermaphros* ELLIS. Coral. p. 122. Tab. 24. fig. g.
- J. arborescens** †
 = *Cor. arborescens* YENDO. Cor. ver. Jap. p. 25. Pl. III. fig. 5 : Pl. VII. fig. 5.
- J. tenella** GRUN. Novara Exp. p. 78.
 = *Cor. tenella* Kütz. Tab. Phyc. VIII. p. 41. Tab. 85. fig. 2.
- J. radiata** †
Cor. radiata YENDO. Cor. ver. Jap. p. 26. Pl. III. fig. 6 . Pl. VII. fig. 7.
- J. pusilla** †
 = *Cor. pusilla* SOND. Alg. Austr. p. 21.
 = *Cor. nana* LENORM. (sec. l. c.)
 = *Cor. Lenormandiana* GRUN. (?) ?

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- J. pygmæa* LAMX. Histoir. p. 269. t. 9. fig. 1.
 = *Cor. pygmæa* Kütz. Tab. Phyc. VIII. p. 37. Tab. 78. fig. 3.
- J. pumila* LAMX. Histoir. p. 269. t. 9. fig. 2.
 = *Cor. pumila* Kütz. Tab. Phyc. VIII. p. 39. Tab. 83. fig. 1.
- J. pedunculata* LAMX. Histoir. p. 269. t. 9. fig. 3. α , β .
 = *Cor. pedunculata* Kütz. Tab. Phyc. VIII. p. 37. Tab. 78. fig. 2.

- J. verrucosa* LAMX. Histoir. p. 269. t. 9. fig. 4. α . β .
 = *Cor. verrucosa* KÜTZ. Tab. Phyc. VIII. p. 38. Tab. 80. fig. 3.
J. parvula ZANARD. Coral p. 21.
J. gibbosa LAMX. Histoir. p. 269.
J. compressa LAMX. Freye. Voy. p. 624. t. 90. fig. 8–10.
Cor. constricta KÜTZ. Tab. Phyc. VIII. p. 40. Taf. 84. fig. 2.
Cor. tridens KÜTZ. Tab. Phyc. VIII. p. 41. Taf. 85. fig. 3.

This genus is sharply distinguished from the others by the great delicacy of its fronds and the regular ramification. The greatest number of the species ramify dichotomously in a plane. *J. decussato-dichotoma* branches in an aberrant manner as was described in my former paper.¹⁾ And it is highly probable that this species has been hitherto reckoned among *J. adherens* LAMX. There are many species closely related to *J. adherens* LAMX., found in the warmer parts of the Atlantic and the Pacific Ocean, such as *J. capillacea*, *J. micrarthrodia f. antennina*, *J. micrarthrodia f. tennissima*, *J. tenella*, *J. novæ-Zelandæ* and *J. unguolata*. The essential distinguishing character lies in the relative size of the articuli. It is a question whether or not it is worthy to serve as a specific character. *J. adherens* LAMX. seems to undergo some change in the minor character. This species stands in the present genus in the same relation as *Corallina officinalis* L. in the *Officinales*.

The articuli are, in the majority of the genus, cylindrical, a few only have compressed ancipitous, and some, slightly complanated articuli. The pinnate ramules, as has been already remarked, are frequently found at the basal and middle portions of *J. rubens* var. *corniculata* and *J. micrarthrodia f. antennina*. At the base of certain species a sort of a delicate ramulet is found in a form of the rhizoidal processes. These ramulets are proliferated

1) Study of Genicula. p. 8.

from the lateral surface of the basal articuli and seem to be of the same nature as those found in some *Corallina*.

J. adharens, *J. pusilla*, *J. radiata*, etc., are always found epiphytic upon other algæ. The first one and some of its allies are mostly upon *Digenia simplex* AG. and the latter two upon *Sargassum*, *Cystophyllum*, *Cystophora* or other brown algæ.

I have several specimens of *J. pusilla* SOND. kindly sent by MAJOR REINBOLD, PROF. MIYABE and others. They seem to have been distributed from the herbarium of DR. F. von MÜLLER, and are named "*Corallina Lenormandiana* = *Cor. nana* LENORM. nec ZANARD." The author of the species was not mentioned with any of the specimens. I am not certain where LENORMAND mentioned the plant. In asking MR. REINBOLD about the matter a few years ago, he answered that he thought the author of *Cor. Lenormandiana* is probably GRUNOW, but not quite sure. So far as I could ascertain, the specific name has never been published.

TOKYO, MAY, 1905.



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ERRATA.

P. 4. Insert next to "*α fusoides* (ARESCH.)"

 = *Amp. Gaillonii* KRAUSS. Beitr. Flor. Caput. p. 206.

P. 5. for "= *Amp. Goddefroyi* GRUN." read "= *Amp. Godeffroyi* GRUN."

P. 8. for "= *Ampiroa corymbosa* HARV." read "= *Amphiroa corymbosa* HARV."

 " for "*Amphiroa constricta* KÜTZ." read "*Amphiroa contracta* KÜTZ."

 " insert next to "*Corallina frondescens* KÜTZ." etc.

Corallina Filicula f. *ramosissima* KÜTZ. Spec. p. 707.

P. 29. for "f. *Farnoensis* KÜTZ." etc., read "f. *farocensis* KÜTZ." etc.

P. 38. for "= *J. plumula* ZANARD." read "= *J. plumula* ZANARD."

